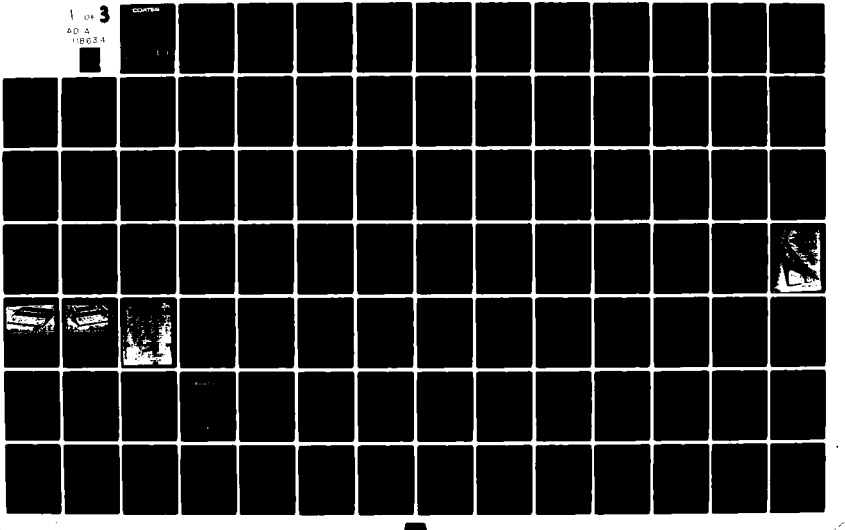
AD-A118 634 COATES (J F) INC WASHINGTON DC F/G 13/8
THE CONSEQUENCES OF METRIC PRODUCTION FOR SMALL MANUFACTURERS. --ETC(U)
FEB 82 H H HITCHCOCK, J F COATES, M M CANAVAN AA-80-SAC-X8604
UNCLASSIFIED NL



(1)

JF COATES INC.

THE CONSEQUENCES OF METRIC PRODUCTION FOR SMALL MANUFACTURERS

Volume II

CASE STUDIES OF LARGE BUSINESS-SMALL BUSINESS INTERACTION

Henry H. Hitchcock
Joseph F. Coates
Marcy M. Canavan
Grant H. Prillaman
M. Suzanne Nettles

February 8, 1982

3738 KANAWHA STREET, N.W. WASHINGTON, D.C. 20015 (202) 966-9307

COATES INC.
1. KANAWHA STREET N W WASHINGTON, D C 20015

THE CONSEQUENCES OF METRIC PRODUCTION FOR SMALL MANUFACTURERS

Volume II

CASE STUDIES OF LARGE BUSINESS-SMALL BUSINESS INTERACTION

Henry H. Hitchcock
Joseph F. Coates
Marcy M. Canavan
Grant H. Prillaman
M. Suzanne Nettles

February 8, 1982

PREFACE

The metric system of measurement is working its way into all aspects of American life: sports, schools, health care, gasoline pumps, wine and liquor, manufacturing, weather reports, and soft drink bottles. The U.S. Metric Board was established as an agency of government to assist individuals, groups, governments, companies, and others who voluntarily choose to convert to using the metric system. One of their missions is research on how conversion to metric occurs and what its effects are on those who convert and on the nation.

Over the last decade, controversy, concern, and conjecture have surrounded the effects of metric conversion on small businesses. Enthusiasts for metric argue that conversion would benefit small businesses in two ways. It would expand their markets -- especially export markets. It would also improve business by making production processes more rational. Dissenters argue that conversion is unnecessary and possibly harmful to the majority of the nation's small businesses. Against this backdrop, the U.S Metric Board is fulfilling its statutory mission to find out what happens to small businesses that convert to metric.

The first phase of the project was a search for small businesses that had made substantial investments in converting to metric.* That search showed that small businesses were most likely to invest in metric production in response to large corporations' needs for metric parts and products. The second phase of the research consisted of three case studies of the effects of large companies' conversion on small business suppliers. The team studied how the conversion of a General Electric Company department, two Ford Motor Company product lines, and three divisions of Ingersoll-Rand affected their small business suppliers.

This is the second volume of a two volume report. Volume 1 summarizes the findings of both phases of the research. Volume II reports the details of the phase two case studies.

---

*Henry Hitchcock and Joseph Coates, The Search for Small Businesses with Investments in Metric Production. (Washington, D.C.: J.F. Coates, Inc., June 1981) NTIS #AD-A 107-860.

Many people contributed to this research. Glenr Keller of General Electric, Randy Rieth of Ford, and Jassie Master of Ingersoll-Rand arranged the case study visits, helped interpret the results, and coordinated the reviews of the drafts. The many helpful people in the divisions studied and the small businesses contacted and visited are acknowledged in the prefaces to the case studies.

At the U.S. Metric Board, Gene Visco, Ed McEvoy, and Stan Parent were attentive, interested, and involved patrons. At J.F. Coates, Inc., Rhoda Baum was responsible for the production of the report. Bernice Mann and Barbara Bullard helped her.

This report was prepared for the U.S. Metric Board under Contract Number AA-80-SAC-X8604. Any opinions, findings, conclusions, or recommendations expressed in the report are those of the authors and do not necessarily represent the views of the U.S. Metric Board, the General Electric Company, Ford Motor Company, or Ingersoll-Rand Company.

VOLUME II

TABLE OF CONTENTS

SUMMARY

SUMMARY

TABLE OF CONTENTS

EXHIBITS

SUMMARY

General Findings

Metric production fits comfortably into relations among large manufacturers and their small suppliers. Working to metric specifications has become a routine part of doing work for large companies.

Many small manufacturers produce metric products. The amounts of production they devote to metric varies widely depending on customer demand for metric. Most small manufacturers make metric products by converting specifications to customary measurements. Few suppliers to large companies have made substantial investments in converting to metric; of 399 small metric suppliers, only five percent spent over $10,000 and considered their investment significant.

Most small manufacturers are doing metric work for several large companies. Consequently, the large companies do not dominate their metric suppliers. Large companies turn to their existing suppliers for metric products; they have not dropped any suppliers as a result of metric conversion.

Small manufacturers see few problems or benefits from producing metric products. Problems of getting supplies or inconvenience often disappear within a year. The major benefit is keeping the business of current customers.

The Case Studies

The general findings above and the detailed findings below come from three case studies of the effects of a large company's metric conversion on its small business suppliers. The case studies cover the effects of conversion at General Electric Data Communications Products Business Department (high speed printers), Ford Motor Company (light trucks and the Ford Escort/Mercury Lynx), and three divisions of Ingersoll-Rand: IMPCO (large machinery), Portable Compressor (air compressors), and Power Tool Roanoke Facility (air starters, hoists, and winches).

Previous research by the study team on small businesses' investments in metric production led to several hypotheses about the role of large businesses

in small businesses' metric conversion. The study team explored these hypotheses through interviews with six divisions of the three large companies, through site visits to nine small manufacturers, and through contacts with 531 other small manufacturers.

Detailed Findings

The Large Companies' Handling of Metric

- Large companies do not distinguish between large and small businesses when they look for metric products. Price, quality and delivery determine suppliers.
- The product lines studied have been converted within the last five years.
- Large companies use metric products that are readily available in the marketplace. They avoid paying premiums for metric products. When they cannot get a metric part without paying a substantial premium, they use a customary part.
- The large companies did not anticipate problems with their suppliers regarding metric production. Only one of the companies contacted surveyed its suppliers about willingness to produce metric products.
- The large companies did not encounter complaints or problems from their suppliers as a result of their conversion to metric. A few suppliers asked for and received assistance in locating metric parts or clarifying metric drawings.
- Most of the large companies use metric-only drawings; they found dual dimensioned drawings increase errors. If a conversion error is made by a supplier, customary practice makes that the supplier's responsibility.
- Metric production fit comfortably into older, established manufacturing practices such as lending tooling to subcontractors, paying tooling, fixture, and gauging costs for suppliers, and collaboration on product design.

The Metric Suppliers

- Of the 540 small manufacturers contacted, 74 percent make metric products. Of the Ford suppliers contacted, 93 percent make metric products. At the other extreme, 50 percent of the Ingersoll-Rand Portable Compressor Division suppliers make metric products.

- The small manufacturers range from a two person prototype shop to a 450 person foundry or fastener manufacturer with an average of 126 employees.

- Small manufacturers make metric products for several different customers, including the large companies studied. Small manufacturers' metric production averaged between 15 percent and 51 percent of their total output for all customers.

- Few small manufacturers actively seek metric business from new customers.

Investment in Conversion

- Of the 399 small metric manufacturers, half use metric at some stage to make metric products: 12 percent use customary dimensions but inspect in metric dimensions; 25 percent use both metric and customary measurements in making metric products; 13 percent work solely in metric. The other half use only customary units to make metric products.

- There is no clear connection between the percentage of total production done to metric dimensions and the method by which those metric products are made.

- Small metric manufacturers invest very little to make products to metric dimensions. Only five percent of the small manufacturers spent over $10,000 converting to metric and considered the investment significant. Another three percent spent over $10,000 but did not consider the investment significant. The other 92 percent spent less than $10,000 converting to metric. Many of the suppliers made no additional investment to produce to metric dimensions.

- Small manufacturers invest in quality control equipment and metric capabilities for new and older machines. Large companies often pay for the initial tooling, fixtures, and gauging suppliers use to make their products. They do this to maintain control over the tools and to enhance their flexibility in the event of labor, financial, or other difficulties. This practice has the side-effect of reducing the suppliers' investments in metric production.

- Many of those companies making substantial investments in metric production chose to pay their own tooling costs to develop a line of metric products marketable to other customers.

Large Company Role in Small Business Conversion

- Small manufacturers generally have several customers for metric products, often in different industries. At the high end, Ford accounts for an average of 43 percent of its suppliers' metric production. At the low end, Ingersoll-Rand Portable Compressor accounts for an average of 24 percent of its suppliers' metric production.

Effect of Conversion

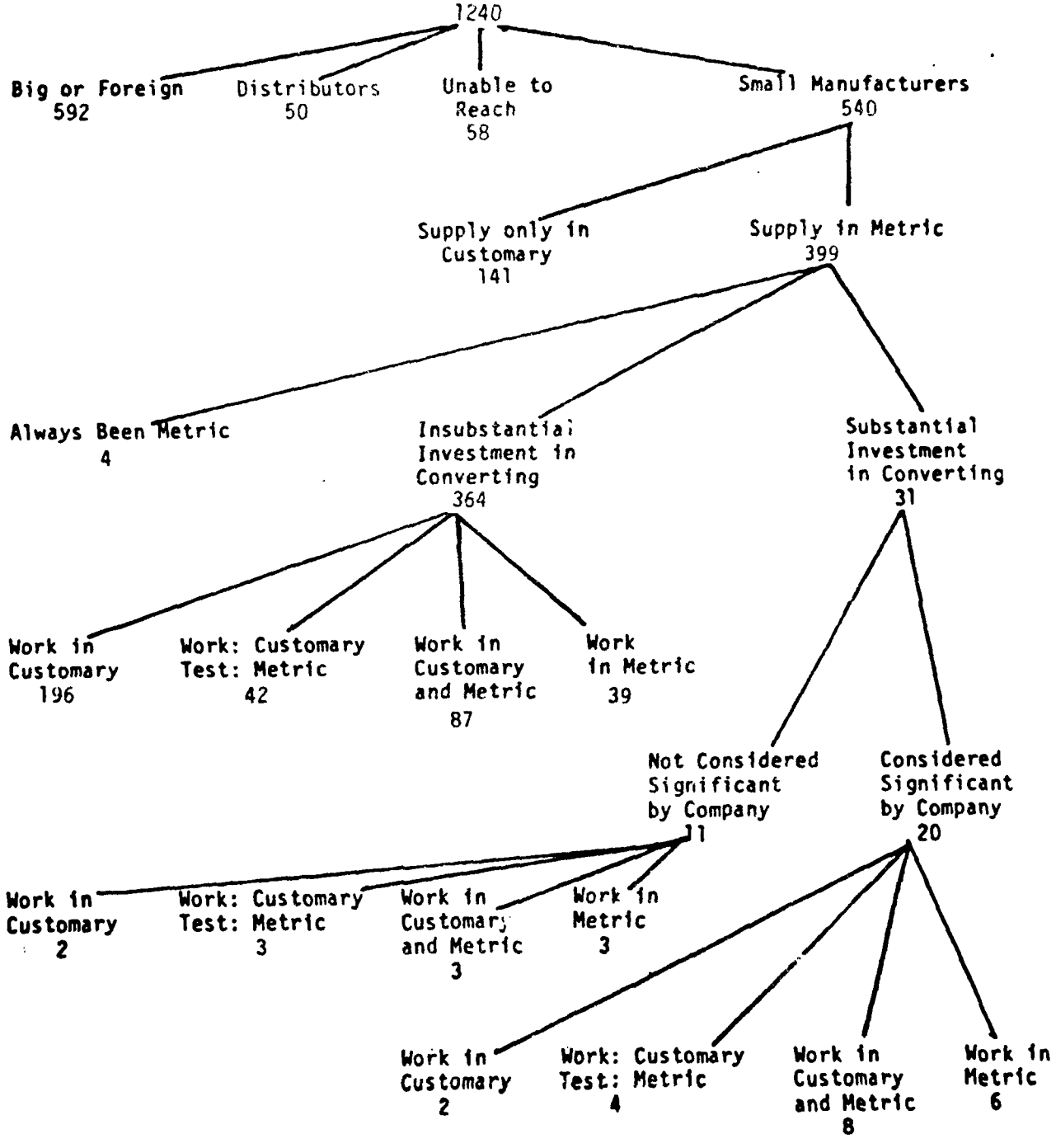
- Business is business. Suppliers do not let metric stand in the way of getting and keeping customers' business.
- Metric has not generally led to the recruitment of new suppliers. But, a few metric hardware distributors have been added to large company suppliers lists.
- Some suppliers mentioned transition problems such as inconvenience and difficulty in finding suppliers.
- Suppliers see few benefits in making metric products beyond keeping their customers satisfied.

Exhibit S-1 summarizes the ways small manufacturers make metric products.

Exhibit S-1

SUPPLIERS' METRIC ACTIVITY
GENERAL ELECTRIC OCPBD, FORD, I-R IMPCO,
I-R PORTABLE COMPRESSOR, AND I-R POWER TOOL ROANOKE FACILITY

Total Number of Suppliers on Lists of Suppliers



BACKGROUND FOR THE CASE STUDIES

BACKGROUND FOR THE CASE STUDIES

TABLE OF CONTENTS

EXHIBITS

BACKGROUND FOR THE CASE STUDIES

Introduction

The metric system of measurement is gaining acceptance in many areas of American life -- from schools to missiles, from weather reports to liquor bottles, from pills to gasoline. As the nation adopts the metric system problems arise. That is the nature of change. Should there be only one official measurement system? What about the costs of dual inventories? What is the effect of conversion to metric on worker job security? On advancement? On collective bargaining? Who pays for conversion -- The consumer? The taxpayer? The corporations which convert? How should they pay? What is voluntary conversion?

These and other issues have been raised in the decades of debate over metric conversion in the U.S. A matter of intense concern has been the consequences of conversion for the nation's small businesses. Enthusiasts of metric conversion argue that metric conversion would be inexpensive and would open new markets, here and abroad. Enthusiasts argue that conversion should be planned and executed within a definite period, so that no one will suffer unduly from conversion. Others argue that conversion is unnecessary for the majority of American's small businesses -- locally oriented retail and service businesses such as dry cleaners, grocers, gas stations, plumbers, clothing stores, and cab companies. Antagonists see metric as most likely to benefit large corporations -- especially multi-national corporations. Labor, small businesses, and consumers would in effect subsidize the conversion benefits for these larger corporations. A factor in the argument against conversion is the belief that the costs of conversion are much larger than the enthusiasts allow.

In discharging its statutory responsibility, the U.S. Metric Board has sponsored research to improve our understanding of the nature and effects of metric conversion among small businesses. This is the second study the USMB has undertaken on this subject. The previous study was a survey of metric activity and attitudes among small businesses. This study shifts the focus from the broad survey to developing a detailed understanding of the costs, benefits, anticipation, problems, and opportunities and outcomes of conversion. An accurate picture could be used to develop policies for easing problems resulting from metric conversion.

The first phase of this study found few costs, benefits, problems, or opportunities for small businesses converting to metric. Most companies spent insubstantial amounts, from their own perspective, in developing a metric capability. Small businesses do not decide to convert independently; they often respond to customer demands for metric -- most often large corporations' demands. The study team, with the concurrence of the U.S Metric Board, changed the focus of the study to case studies of the interaction of large and small businesses on metric conversion. By focusing on suppliers to large companies these case studies are likely to find those small businesses making substantial investments in converting to metric. Also, analysis of small business-large business interaction on metric sheds light on a critical but largely ignored force behind metric conversion of American business.

This chapter gives the background for the case studies of large business-small business interaction on metric conversion. The sections on the purpose of the study, the first phase findings, and the purpose of the case studies, identify the scope and direction of the research. The sections on hypotheses guiding the case studies, the case study approach, and selection of case studies give more detail.

The Purpose of the Study

This research on the costs, benefits, problems, and opportunities facing small businesses converting to metric extends the work of a previous survey which covered:

- the level of conversion among small businesses in manufacturing, wholesale and retail trade, construction, and transportation;
- factors related to the decision to convert;
- the types of assistance sought while converting;
- the ways small businesses made their views known about metric conversion to public policymakers;
- views of small businesses on the future of metric conversion.

That survey of 1100 small businesses around the country concluded that a modest but significant amount of metric production had been developed with few problems as a result of demands from the firm's customers or suppliers.*

Where this previous survey yielded atomic or highly discrete data on the state of metric conversion, the present research provides integrated, holistic accounts of conversion experiences. The goals, according to the USMB solicitation, are:

- an assessment of the actual costs and benefits of conversion experienced by small businesses;
- a detailed review of the alternative forms of representation (voices or channels) available to the small business community.

On the issue of costs and benefits, the solicitation asks the analysis to:

- determine the direct and indirect, monetary and non-monetary costs and benefits to selected small businesses and industries which have converted to the metric system. Of major interest are conversions to hard metric units, that is, products made to metric dimensions, with lesser interest in cases of soft conversion (metric labeling of products made to customary units). Costs include cost and availability of credit.

The study team proposed research based on describing the conversion experience of clusters of small businesses. These clusters would consist of:

- a relatively large-size small business which has undergone hard metrication, and which was not previously involved in metric-related activities, e.g., not a scientific instrument supplier;
- from the suppliers to that company, a small business impacted by the hard metrication;
- on the output side, customers of the company, potentially or in fact, impacted by hard metrication.

*Damans and Associates, Survey of Small Businesses: Issues in Metric Conversion and Planning. Prepared for the U.S. Metric Board, December, 1980.

Exhibit A shows the cluster concept. For each cluster, the research would develop: (a) a qualitative description of conversion to metric, including the way the decision was made, how the conversion took place, who was involved, the kinds of problems that occurred, the kind of help sought and received, and the implications of conversion for the business; and (b) a quantitative accounting of the costs and benefits of conversion that would look in depth at the micro-economics of the many decisions that comprise the conversion to metric production.

Underlying the study approach were several assumptions, including:

- the most likely place to find costs and benefits of conversion is in companies producing hard metric products; dual labeling (soft conversion) is not likely to involve significant costs or benefits.
- some businesses have made substantial investments in converting production to hard metric production;
- these businesses are easily identifiable and numerous;
- these businesses will be willing to talk in depth and detail about their conversion experience.

First Phase Findings

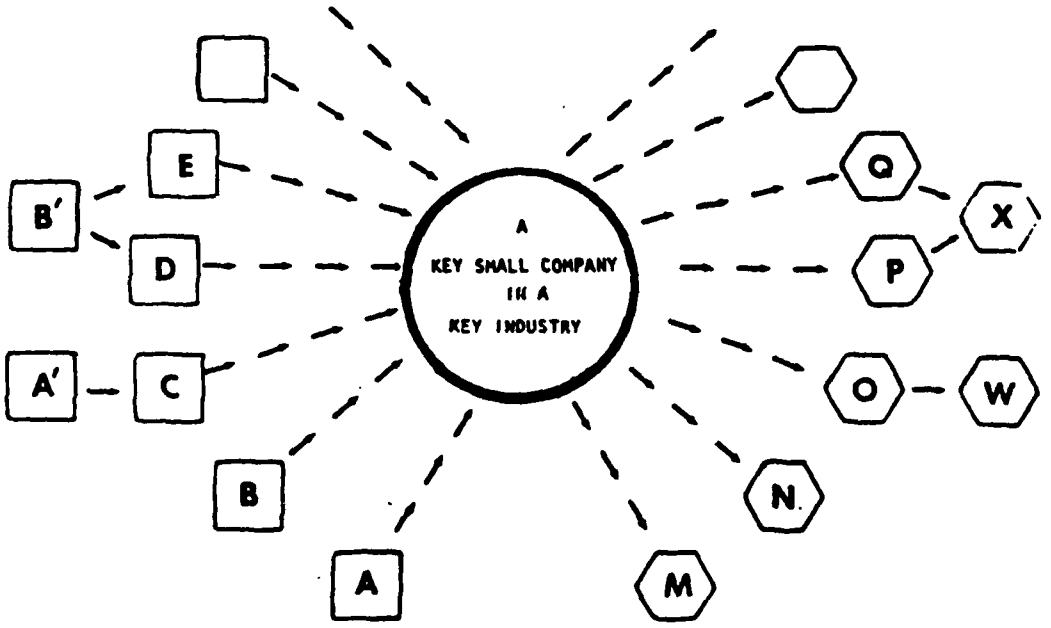
To refine this analytical approach, the study team wanted to interview several companies which had successfully converted to hard metric production and at the same time locate companies that might qualify as key companies for in-depth analysis of clusters of small businesses.

The project team overestimated the number of companies investing in converting to metric and the size of their investment. While the team got valuable information from the people it talked with, it was unable to find successful converters or to locate possible key companies easily. As a result the work expanded into an extensive search.

The search strategy was evolutionary and convergent. In looking for substantial investors in metric conversion, many sources were used: the metric literature, trade press, trade and business associations, informed

EXHIBIT A

COMPANY ELEMENTS OF AN INTEGRATED ACCOUNT OF A SECTORIAL CONVERSION TO METRIC



observers, large corporations, and companies contacted in previous USMB research. A comprehensive and intensive search was made of the industrial base of Pennsylvania and Maryland -- states with many diverse industries. The following conclusions are derived from contacts with 1,161 businesses -- small businesses (868) and the large businesses they supply (293).

General Finding

There is a widespread capability among the nation's small businesses to produce metric products. However, the investment and extent of conversion for most small businesses is very small and unimportant. Developing a metric capability is seen by most businesses as a routine, unexceptional, necessary cost of doing business. Conversion to metric by small businesses is usually the result of demands from current customers -- especially large corporations. Few small businesses have converted to increase foreign sales. The capability developed by small businesses to produce metric products is widespread but shallow. Unusual or big demands for metric products are likely to be difficult for most small businesses to handle with present capabilities.

Number and Investments of Metric Small Businesses

From this directed search for small businesses making substantial investments in metric conversion, only a handful of companies (a) considered their investment substantial, and (b) spent over $10,000 in converting to metric. Specifically:

- Three companies spent over $10,000 on conversion and considered the investment substantial; another four spent over $10,000 but did not see the investment as substantial. These seven represent less than 1% of all the small businesses contacted -- less than 3% of all the metric producing small businesses contacted.
- Three of every ten small businesses contacted made hard metric products. Most of these companies made insubstantial investments in conversion -- by their own estimate and in terms of the $10,000 threshold. Several companies had always produced metric products.

- The other seven out of every ten small businesses contacted continue to produce using only customary dimensions.

Findings on the Conversion Process

In the course of contacting these 1,161 companies, a number of interesting and important findings concerning small businesses' conversion emerged:

- Small businesses convert part of their production to metric because of customer demands. Usually the customer is a large corporation that has converted to metric.
- Few companies convert more than a very small percentage of their production to metric.
- Most companies respond to a metric request by converting it into customary units and producing it using conventional machines.
- Conversion has cost small businesses very little. Most companies spent less than $5,000, often around $1,000, converting to metric. Low cost electronic dual readouts have made conversion easy and relatively inexpensive.
- Conversion occurs on the margin. Most businesses do not shift to metric all at once. As new machines are ordered or new tools bought, small businesses purchase tools and machines that can produce in both metric and customary units. Few make major purchases solely for metric production.
- Conversion to metric is often spurred by the need to repair, modify, or replace foreign machinery. In a number of industries such as mining, candy machinery, and electron microscopes, machinery is made overseas. To fix this metric machinery, local suppliers and service companies must begin to work with metric dimensions.
- Metric activity is greatest in the machine and fabricated metal products industries -- industries making products for other industries. Metric has made few inroads to the highly diffuse consumer industries, such as food, apparel, leather goods, and furniture.

- Large corporations often assist their small business suppliers in meeting their metric demands. It is in both parties' interests.
- There is little awareness of, or interest in, sector planning related to metric conversion. Conversion occurs on an individual company level; few companies know of others in their area or their industry that have converted to metric.

Interpretation

The importance of small businesses to metric conversion has been highlighted repeatedly -- in Congressional reports on metric, in the language of the Metric Act of 1975, in the inclusion of small business representatives on the U.S. Metric Board, and in the establishment of a Small Business Advisory Group of the American National Metric Council. The effect of conversion on small businesses has been a central concern in the metric debate. To characterize the past decade's debate, at one extreme stand the metric enthusiasts who see benefits to all in a rapid and complete shift to metric production. At the other extreme are the hard-line traditionalists who see little justification for metric conversion -- an unnecessary, non-competitive waste of resources. The first phase findings have implications for the issues relating to:

- the extent of conversion;
- the cost of conversion;
- the nature of conversion;
- the motivation for conversion;
- the equity of conversion;
- the pace of conversion;
- the future of conversion.

Exhibit B shows the implications of the study findings on each of the seven issues. The dart (▲) on the scale indicates the pole of the controversy the findings favor. For example, if the dart is near the enthusiasts position, as in the case of costs, the findings favor the enthusiasts' interpretation of that particular issue. The findings support both positions but on different issues. On several issues they come down close to the middle.

Purposes of the Case Studies

The search for small businesses with substantial investments in metric production revealed a widespread but shallow metric capability purchased at low cost in response to large customers' demands. If small businesses are making substantial investments in converting to metric, they are most likely doing so as a result of extensive conversion by one or more large corporations. The study team, with the concurrence of the U.S. Metric Board redirected the research to in-depth analyses of the interaction of large and small businesses converting to metric. By focusing on the relations between large and small businesses these analyses extend understanding of the issues surrounding the metric debate concerning small businesses:

- Costs of conversion - If costs are being incurred by small business converting to metric it is most likely to be a result of large customers' conversion.
- Nature of conversion - Most small businesses produce metric products using customary units. This may no longer be practical where demand for metric products is substantial as a result of a large company's conversion.
- Motivation for conversion - Most small companies say they have not made an independent decision to convert but have been forced by their customers. By looking closely at suppliers to large customers the analysis will identify how that forced conversion occurs. It will also look at the role of other motivations, such as search for foreign markets, adding new domestic customers, expanding business with existing customers.

EXHIBIT B

FINDINGS ON THE ISSUES CONCERNING METRIC CONVERSION AND SMALL BUSINESSES

Issue	ENTHUSIASTS		HARD LINERS
Extent of Conversion	Widespread in many industries	x ▲ . . . 0 x	Moving slowly; few industries
Cost of Conversion	Trivial costs with caution	x ▲ . . . 0 x	Possible major economic losses
Nature of Conversion	Hard conversion of products and processes in many areas	x . . . . 0 . . . ▲ x	Dual measurement; conventional measurement clearly dominates
Motivation for Conversion	Voluntary search for new markets - home and abroad	x . . . . 0 . . . ▲ x	Involuntary conversion forced by demands from large corporations
Equity of Conversion	All will benefit	x . . . . ▲ x	Multinationals benefit at the expense of small businesses.
Pace of Conversion	Rapid and complete	x . . . . ▲ x	Ad-hoc, as needed
Future of Conversion	Complete conversion in the near future	x . . . . ▲ x	Limited conversion over the long term; consumer never converts

- Equity of conversion - What are the benefits and costs to small businesses converting in response to large corporations' conversions? Is the large corporation benefiting from conversion at the expense of its small business suppliers?
- Pace of conversion - When a large customer converts to metric, how does that influence the extent of conversion within the small business? What level of large corporate demand for metric leads to substantial investments in metric conversion and the development of an extensive metric capability?

Analyses of large business-small business interaction on metric conversion can reveal how small businesses' widespread but shallow capability for producing metric products responds to a marked increase in the demand for metric. Does this surge create problems or costs for small businesses? Or are they able to handle it without significant dislocation or perturbation?

In addition to clarifying policy issues surrounding small business conversion to metric, case studies of large business-small business interaction on metric:

- Address a critical dynamic of conversion in U.S. industry that has been largely ignored in previous research;
- Result in detailed accounts of how conversion occurs in different industries;
- Help other industries plan conversion;
- Help federal, state, or local agencies understand the implications of their actions for small businesses;
- Identify successful approaches in industry's handling of the problems of suppliers' or customers' conversion.

Hypotheses Guiding the Case Studies

The findings of the search for small businesses with substantial investments in converting to metric lead to several hypotheses about the interaction of small and large businesses on metric conversion. These include:

- If there is significant investment by small businesses in metric production, it is most likely the result of a large business' conversion.
- A small business' metric production is likely to be dominated by one large corporate customer.
- The demands of a large corporate customer stress the ability of a small firm to meet the demands by converting to customary units.
- Conversion of small businesses to meet the needs of large businesses requires cooperation between large and small businesses to help the small businesses weather the conversion and decrease the costs of conversion to the large business.
- The stresses of metric conversion cause a shift in the suppliers and customers of a large corporation; those who can not or will not convert stop dealing with the company while those who will produce metric expand their business with the larger firm or are recruited by the larger firm.
- The more extensive the large corporations' conversion to metric, the more likely these hypotheses will be borne out.

The case studies focus on these hypotheses in terms of the effects of the large company's conversion on the small business, how large businesses help small businesses, who dominates small companies' metric business, and how suppliers to the large company change when it converts.

The Case Study Approach

Case studies have several advantages in analyzing the unexplored, complex interactions of large and small businesses on metric conversion. First, case studies can investigate hypotheses while also developing new hypotheses based on interim findings. Second. case studies use many paths to uncover the complex relations between small businesses and their large customers. Third, case studies allow a degree of flexibility essential in exploratory research.

Fourth, case studies of large business-small business interaction on metric result in detailed, holistic accounts of conversion experiences -- accounts that can be used to inform policy or identify areas in need of additional research.

The case studies of large business-small business interaction on metric closely resemble the original plan for investigating clusters of small businesses. The main difference is that the center of the activity is a large business and the focus of the attention is on the small business suppliers to the large business. Several factors contribute to the difficulty of looking at the customer side:

- Few firms are willing to identify their customers.
- The list of customers for many large companies is extensive, diffuse, and difficult to use for purposes of this research.
- Many customers are not manufacturers but wholesale or retail organizations.
- Those most likely to be affected are service organizations -- they do not make investments in production but provide service on hard metric products.

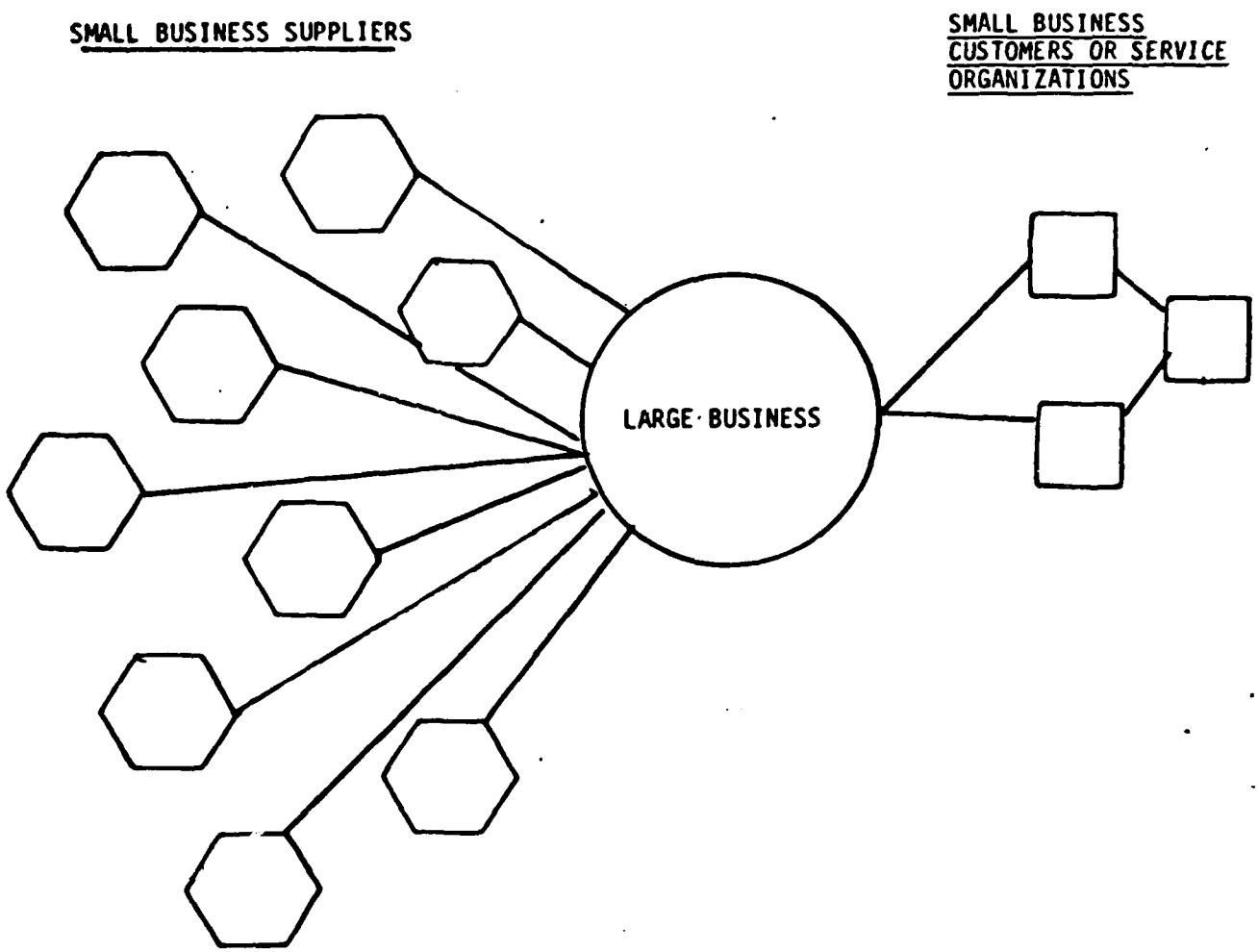
Where feasible, the case studies do some preliminary investigation of the aftermarket effects of large companies' conversion. However, the study focus on investments in hard metric production leads to a primary interest in the suppliers of the large company. Exhibit C illustrates the case study concept.

A case study involves a large business, its small business suppliers, and (to a lesser degree) its small business customers or service organizations. In looking at these different actors, the case study pursues two key questions:

- How has the large company's conversion affected its small business suppliers and customers?
- How have considerations of small businesses' ability to provide metric products affected the way the large company has converted to metric?

EXHIBIT C

LARGE BUSINESS SMALL BUSINESS INTERACTION ON METRIC: CASE STUDY CONCEPT



In pursuing the first question the study team looked for the costs, benefits, problems, and opportunities faced by small businesses when a major supplier or customer converts to metric. What does it cost to produce to metric dimensions? Is new equipment required? Are new people needed? Is there an increase in problems such as errors on production drawings, late deliveries, increased rejections of supplier parts, more warranty work, and the like? For the second question the key points were how small business customers and suppliers are perceived by the large business and how those perceptions affect the large company's conversion. For example, if a large company feels its suppliers cannot supply a metric part such as a transformer, at reasonable rates, it may choose to continue to order transformers in customary units.

In addressing these two questions the study team identified four distinct types of large company conversions:

- Prototypes: In the engineering and design phase of the product lifecycle, models or prototypes are built to test the concept. These require parts from external suppliers.
- Parts for production: When a product goes into production, a large company needs parts and sub-assemblies from external suppliers. They may go to outside companies because they are not equipped to make the product, the supplier makes a better product, the supplier makes a cheaper product, or they do not have any available production capacity. The large company may purchase standard items such as nuts and bolts or custom parts such as stampings or plastic molded parts.
- Production equipment: Large companies may turn to small businesses for modifications of existing production equipment or for new equipment -- taps, drills, digital dual readouts, milling machines, lathes, drill presses, inspection equipment, and the like.
- Product service: Small business may be involved in modifying or servicing the products of large businesses -- for example, the small service station that works on a Ford with a metric engine.

These different types of conversion reflect different stages of the product lifecycle from concept to modification and repair. Departments of the large company and types of small business involved in conversion differ depending on the stage of the cycle.

To investigate these two key questions over the four phases of the product lifecycle, the study team talked to the large company, the supplier, and the customer. Exhibit D shows the generic case study approach. The steps of the approach were:

- Identify large company for study - see below for discussion of selection criteria and process.
- Obtain large company cooperation - the study team first sought cooperation from the corporate offices. This was usually followed by similar requests of the specific divisions working in metric. Exhibit E is the fact sheet about the project which was sent to prospective large companies.
- Interview large company departments - within the specific divisions of the large company working in metric, the study team asked the involved departments, a) what effect they have had on their small business suppliers and customers, and b) how considerations of small suppliers and customers have affected their approach to metric conversion. Among the departments consulted were:
    - Engineering
    - Engineering Standards
    - Industrial or Manufacturing Engineering
    - Purchasing
    - Quality Assurance
    - Product Service

  Exhibit F illustrates the questions addressed in these interviews.

EXHIBIT D

CASE STUDY FLOW

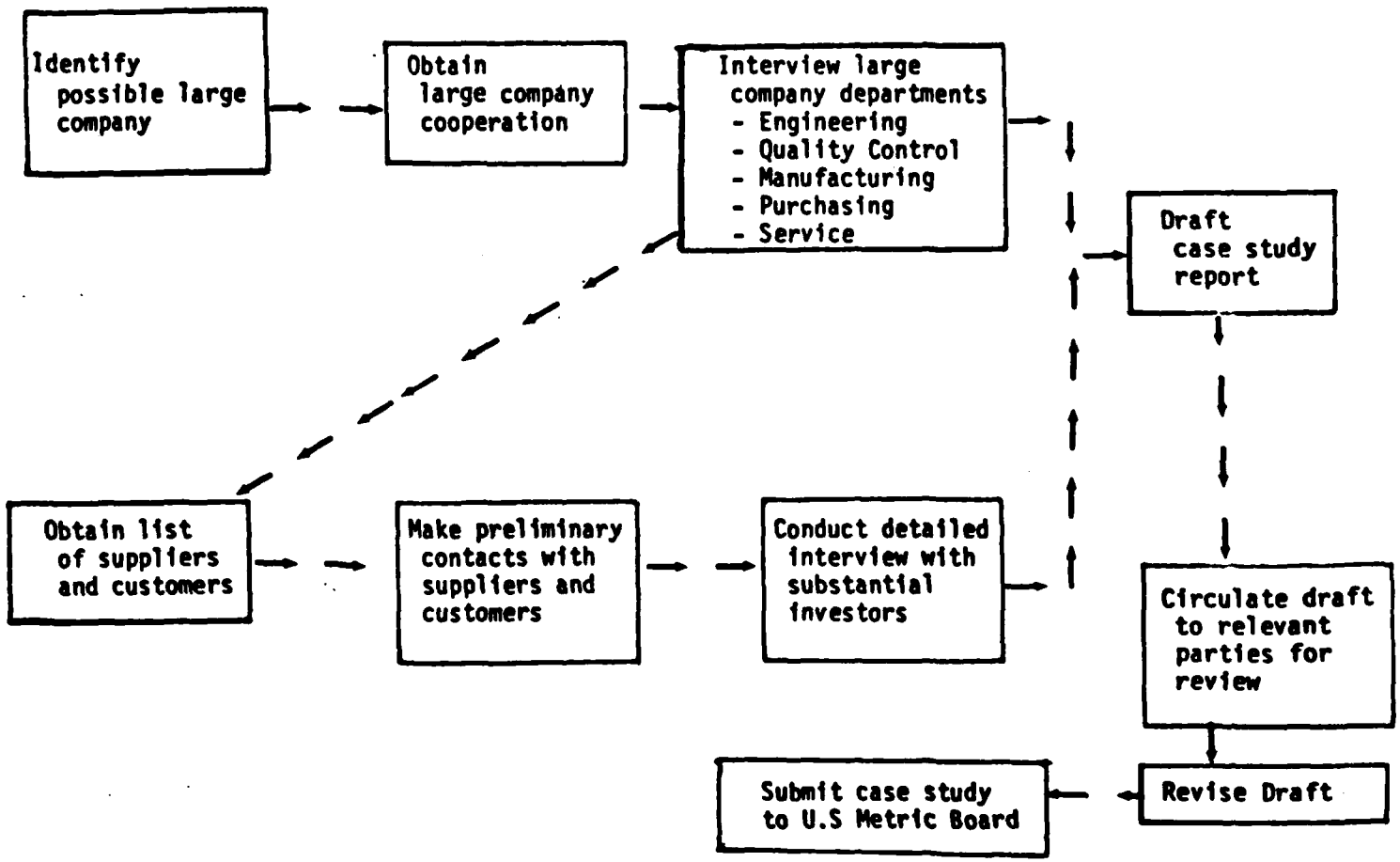


Exhibit E

FACT SHEET: PROPOSED CASE STUDIES OF SMALL BUSINESS SUPPLIERS OF METRIC PRODUCTS TO LARGE CORPORATIONS

Who we are:

J.F. Coates, Inc. is a new research firm in Washington, D.C. specializing in policy and futures research. We have research and training contracts with several government and private clients. The enclosed broadsides give more information.

The Project:

Our current project for the U.S. Metric Board concerns the conversion of small businesses to the metric system. Its goal is to develop through case studies a detailed understanding of the costs, benefits, problems, and opportunities associated with small businesses' conversion to metric.

The Sponsor:

The U.S. Metric Board, an agency of the U.S. Government, by law assists those who voluntarily convert to the metric system. Our project is part of the Board's systematic research program to improve the basis of public and private metric policies and plans. Enclosed is a copy of the U.S. Metric Board's 1980 Annual Report.

Our results so far:

Over the past 8 months, we have contacted 1100 companies -- large and small -- looking for small businesses which have made substantial investments in converting to metric. We found a widespread capability to produce metric products among small businesses developed on the basis of very small investments. There have been few problems with conversion among the small businesses we contacted.

Why we are turning to you:

Our research found the major driver of small business conversion to the metric system to be orders from their large corporate customers. The relations between small business vendors of metric products and large corporate users of metric products are therefore central to understanding the nation's gradual, voluntary conversion to the metric system. To increase our understanding of this important facet of conversion, we are directing the current research to case studies of the relations between large companies and their small business suppliers of metric products.

EXHIBIT E: Fact Sheet (continued)

Why you:

As a large company producing metric products and user of small business suppliers, you are among the pioneers in metric conversion in the United States. We want to take advantage of the path-breaking experiences of you and your small business suppliers to inform the actions of those who may follow you - other large companies, small companies, and even government agencies. The focus in the case studies will be on the transferrable lessons from your experiences. We anticipate the case studies will result in positive and useful accounts of corporate-small business cooperation.

What we request:

With your approval and cooperation, we would:

- Visit your headquarters or specific division for several days to talk to a dozen or so of your people who are closely involved in metric production and purchasing. These people could come from standards, engineering, purchasing, materials, manufacturing, or related departments. In these 1/2 hour discussions, we would ask about your general strategy for converting to metric and how that strategy has affected your relations with small business vendors. Having developed an understanding of your general strategy, we would move to the main focus of the project - your small business suppliers; during our conversations we would be developing a list of your small business metric suppliers - preferably covering a range of suppliers in terms of size and type of product.

- Make preliminary telephone contacts with some of your small business suppliers to describe our project, discuss their conversion experiences, and evoke their cooperation. We anticipate these preliminary contacts would take no more than 1/4 hour each to complete.

- For those cooperating suppliers who have made substantial investments in converting to metric, we would visit with the company for an hour or two for fuller discussions of their conversion experiences.

- From discussions with your company and your small business suppliers of metric products, prepare a report describing the costs, benefits, problems and opportunities associated with conversion.

- Circulate the report to your company and those small suppliers covered in depth from review and comment.

- Revise the report in light of your comments and return it for final revise.

- Incorporate the report in our final report to the U.S. Metric Board.

EXHIBIT E: Fact Sheet (continued)

What your cooperation implies:

To complete the case study, we anticipate spending 1/2 hour to an hour with a dozen of your company's people, 1/4 hour with 50 to 100 of your small business suppliers, and an hour or two with at most 6 of your suppliers who have made substantial investments in converting to metric. We will cover all our direct costs for the week to 10 days we expect it will take to complete the case study discussions. While there will be no direct costs to you, there will be the inevitable costs of spending time with us. We feel these costs will be more than offset by your satisfaction from helping others who may follow you in metric conversion and the knowledge that you have contributed to the nation's understanding of metric conversion, under a voluntary system.

EXHIBIT F

Detailed Questions for Large Company Interviews

1. WHAT DO YOU MAKE?

What products do you make?
How many do you make a year?
What are your annual sales?
What do you do to the product - manufacture, machine, assemble?

Describe how a product is made - design, equipment/tools used, manufacture, service.

2. WHICH PRODUCTS ARE METRIC?

Which of your products are made to metric dimensions?
What percent of your total production is metric? (in no. of units)
When did you convert to metric products? Why?
Why did you convert the products you did and not other products?
Who made the decision to convert?
Were suppliers involved in your decision to convert? Directly? Indirectly?

3. WHO SUPPLIES YOUR METRIC PARTS?

What parts of your product are made to metric dimensions?
What percent of metric parts are supplied by outside suppliers? Is that different from customary?
Why do you use outside suppliers for parts and equipment?
Do you use more or fewer suppliers for metric than for customary parts?
How do you identify suppliers? Different for metric?
How do you select suppliers? Different for metric?
Are there any differences for metric suppliers in terms of: quality, size of orders, delivery times, service?
Who are your metric suppliers? Get names/cities/phone numbers if possible.
Before converting, did you assess the willingness or capability of your suppliers to produce to metric dimensions?

4. HOW MUCH DID IT COST TO CONVERT TO METRIC?

Do metric parts cost more than similar customary parts?
How do you order metric parts? Per piece or tooling costs plus piece cost?
Did you have any costs from delayed deliveries because of metric?
Has there been an increased rejection rate for supplier parts as a result of metric?
What have you bought to develop a metric capability?
new equipment? quality control equipment?
tooling? modifications to equipment?
Would have bought these if you were not converting to metric?
Do you work in customary or in metric units on the factory floor?
How much time is spent converting from metric drawings to customary dimensions?

EXHIBIT F: Detailed Questions for Large Company Interviews (continued)

Do the workers buy their own tools?
Did the company assist the workers in any way in purchasing metric tools?
Do your metric products cost more than similar customary products?
How much do you spend a year on capital equipment?
On tooling? On quality control equipment?

5. WHO SERVICES YOUR PRODUCTS?

How are your products serviced?
Is this any different for metric products?
How do servicability issues enter design considerations?
Have there been any service problems related to metric?
Has the service of your equipment changed as a result of metric?
Have the servicers of your products had to make substantial investments as a result of your conversion to metric?

6. HAVE THERE BEEN ANY PROBLEMS WITH YOUR METRIC SUPPLIERS?

Have suppliers dropped from your list because of metric?
Have suppliers been added because of metric?
Have suppliers requested any assistance in working with metric:
conversions? tooling costs? supplier leads?
calibration of equipment? tooling? other?
people? training?
Is this assistance unusual? Why is it provided?
How do your suppliers produce your metric products? Convert to customary?
Have your suppliers had to make substantial investments to convert to metric?
Have some suppliers increased their share of your business as a result of metric?
How much of your suppliers business do you account for?
How much of their metric business do you account for?

7. HAS IT PAID OFF?

Has metric conversion been more or less of a problem than anticipated?
Have you benefited from converting to metric?
Would you do it differently today?
Were you in the forefront in your industry?
Has your conversion hurt your suppliers? Has it benefited them?
What does the future hold for metric and your relation with your suppliers?

- Obtain lists of suppliers - During the interviews with the large company departments, the study team asked for lists of suppliers of prototype parts, production parts, production equipment, and of service organizations. Sometimes the companies provided lists of all their suppliers for a particular plant or division. In other cases, they provided only those suppliers who are most active in metric.

- Make preliminary contacts with suppliers and customers - The study team called suppliers and customers provided by the large company to see if they have made substantial investments in converting to metric in response to the large company's conversion. The study team also asked if there have been any problems or benefits for the small business as a result of conversion to metric. Exhibit G shows the questions used in this preliminary phone search.

- Conduct detailed interviews with substantial investors - If any of the companies contacted indicated they have made substantial investments converting to metric and the investment was greater than $10,000, the study team attempted to visit them for detailed interviews. These interviews covered:

    - what was converted
    - how was the conversion decision made
    - why the company converted
    - the costs of conversion
    - the problems of conversion
    - any assistance asked for or received
    - the overall evaluation of conversion.

  Exhibit H shows the detailed questions used in these interviews. In two of the case studies, no detailed interviews were done since none of the companies contacted made substantial investments in converting to metric.

EXHIBIT G

Questions Used in Search
for Substantial Investors in Metric Production

Preliminary Screening Questions

1. Are you a small business, less than 500 employees?
2. Are you an independent business?
3. Do you make a metric product for a large company? What?
4. What percentage of your business is in metric?
   Of that, how much is related to a large company?
5. Have you made a significant investment in converting to metric production?
6. Have you had problems in converting to metric?
7. How did you learn of the large company's conversion to metric?
8. Have you benefited from converting to metric?

EXHIBIT H

Detailed Questions for Small Businesses on Metric Conversion

1. WHAT DO YOU MAKE?

What products do you make?
How many do you make a year?
What are your annual sales?
What do you do to the product? Manufacture, machine, assemble, combination?
Describe how a product is made - design, equipment/tools used, manufacture, service.

2. WHAT PRODUCTS ARE METRIC?

Which of your products are made to metric dimensions?
What percent of your total production is metric? (in no. of units)
When did you convert to metric products? Why?
Why did you convert the products you did and not other products?
Who made the decision to convert?
Were customers involved in your decision to convert? Directly? Indirectly?

3. HOW WAS THE DECISION TO CONVERT MADE?

Who made the decision? When?
Were there distinct phases?
Was there a detailed plan?
Who was consulted:
- within the company?
- suppliers, customers?
- associations and others?

Who was involved in the planning?
How was the conversion timed? Why that particular timing?
Why did it end when it did?

4. WHY DID YOU CONVERT?

What were the reasons given?
Were there projections of costs? Are they available?
Were there projections of benefits? Are they available?

5. HOW MUCH DID IT COST TO CONVERT TO METRIC?

Do metric parts cost more than similar customary parts?
How do you order metric parts? per piece or tooling costs plus piece cost?

EXHIBIT H: Detailed Questions for Small Businesses (continued)

Did you have any costs from delayed deliveries because of metric?
Has there been an increased rejection rate for supplier parts as a result of metric?
What have you bought to develop a metric capability? new equipment? quality control equipment? modifications to equipment? tooling?
Would you have bought these if you were not converting to metric?
Do you work in customary or in metric units on the factory floor?
How much time is spent converting from metric drawings to customary dimensions?
Do the workers buy their own tools?
Did the company assist the workers in any way in purchasing metric tools?
Do your metric products cost more than similar customary products?
How much do you spend a year on capital equipment? on tooling? on quality control equipment?

6. DID YOU HAVE ANY PROBLEMS?

When did you encounter these problems?
How did you cope with the problem?
- did you have labor problems?
- problems with suppliers?
- problems with customers?
- problems with local government?
- problems with state government?
- problems with federal government?

7. DID YOU NEED ANY ASSISTANCE IN CONVERTING?

What types of assistance did you get in converting?

- training materials
- training courses
- personnel
- conversions
- tooling costs
- tooling
- gauging
- supplier references
- calibration of inspection equipment

Are these types of assistance unusual in your industry?
To whom did you turn for help?
Why did you choose these organizations?
Was the assistance valuable? What was most useful? Why?
Do companies now turn to you for assistance?
Do you belong to any trade or business associations?
Are your associations active on metric issues?
Have you used your associations for assistance on metric conversion?
Would you turn to an association for assistance on metric?

EXHIBIT H: Detailed Questions for Small Businesses (continued)

B. HAS IT PAID OFF?

Did conversion cost more or less than expected?
Where were the major discrepancies?
Were the benefits what you expected?
How do you know what the costs and benefits of conversion are?
How has your business changed as a result of conversion?
Would you do it differently if you were starting today? How?
Would you provide your records of the conversion process for study?

- Draft report - Based on the interviews with the large company, the preliminary contacts with suppliers and customers, and the detailed interviews with substantial investors, the study team drafted a case study report. The report covers the effects of the large company's conversion on its small business suppliers and customers and the effects of supplier and customer considerations on the metric conversion of the large company.

- Circulate draft for review - The draft report was circulated to those people interviewed for their review. The sections discussing a particular company were sent only to that company for review. Companies contacted solely by phone are not identified in the report and did not review the draft.

- Revise draft - Based on reviewers comments the draft report was revised.

- Submit case study report - After the case study report had been reviewed and revised, it was submitted to the U.S. Metric Board.

After the cases were completed, the study team developed a summary overview of the case study reports. This summary addresses the similarities and differences among the different cases. It also draws out the implications of the case studies for the hypotheses guiding the case studies and the policy issues surrounding the debate over the effect of metric conversion on small businesses. (See Summary, Volume I and Volume II.)

How Cases are Selected

To be useful to the case studies of small business-large business interaction on metric conversion, the large company selected must have several features:

- Willingness to cooperate: These case studies were not possible without the active cooperation of the large company.
- Completed conversion: The large company has to have converted some or all of its products to metric. A company that is in the midst of conversion or is planning to convert is unlikely to have had much of an impact on its suppliers or customers.
- Significant amount of conversion: The most useful large companies are those that have converted a substantial portion of their production to metric; they are most likely to have caused small suppliers and customers to make substantial investments.

- Numerous small business suppliers: To be of interest to this study the large company must use outside suppliers and many of those suppliers must be independent businesses with less than 500 employees.
- Market related conversion: This study was not interested in large companies that had converted as a result of non-market conditions such as NATO purchases or the BATF regulation of liquor and wine bottles. The study concerns how the market copes with conversion.

In addition to these essential features, the study team was looking for large companies having the following features:

- Diverse small business suppliers: For the most yield from the case study, the study team sought large companies that use small businesses for a diverse group of products from bolts to software.
- Not studied before by U.S. Metric Board: By looking at companies not studied by the USMB previously, these case studies would yield the most information for the Board on the nature of conversion in the United States.
- Credible: The studies should be easily believed by the USMB and other audiences. Credibility requires the ability to contact and interview a variety of departments and suppliers. Without this ability the case validity is jeopardized.
- Interesting: If possible the study team selected companies making products easily recognizable or understood by the many audiences for the report.
- Generalizable: To increase the value of the case studies, the study team sought large companies making products or in market situations similar to those of other industries.
- Nearby: To minimize costs, the study team looked for companies in the East, South, North Central regions with most of their suppliers also in those regions.

Based on the previous search for small businesses converting to metric, consultations with informed observers, the literature on metric, and referrals from other large companies, the study team identified 25 possible large companies for study. The team contacted these 25 companies and discussed the possibility of a case study. Based on these discussions, the study team and the U.S. Metric Board used the criteria discussed above to select the three case studies presented below.

What Follows

The case study reports are separate, freestanding documents. Each tells a different story. They have some similarities. Each covers how conversion changes the ways a large company interacts with its suppliers and customers and how conversion has affected small suppliers and customers. Each reports on the general level of metric involvement and investment by suppliers to the large companies. Some cover customers in more depth than others; however, customers are not a major focus in any of the case studies. Some of the case studies involve detailed discussions of specific small businesses. Others do not. The case studies reflect the diversity of experience that characterizes American industry's response to metric conversion. The implications of the case studies taken together are discussed in the summary section (above) and in the Volume I: Summary Report.

REPORT TO THE U.S. METRIC BOARD

LARGE BUSINESS-SMALL BUSINESS INTERACTION ON METRIC CONVERSION

CASE STUDY

GENERAL ELECTRIC COMPANY

--DATA COMMUNICATIONS PRODUCTS BUSINESS DEPT.
Waynesboro, Virginia

Henry H. Hitchcock
Joseph F. Coates
Marcy M. Canavan

PREFACE

Metric measurement is increasingly common in American life -- from missiles to soda bottles, from weather to track events, from machine tools to liquor bottles. This conversion to metric measurement has raised controversy in stores, homes, schools, legislatures, factories, and offices. Why do we have to go metric? Why are we the only ones not using the metric system? When will we completely convert? Does everything have to be changed -- even football fields?

Concern and controversy have been particularly strong regarding small businesses. Will conversion hurt or help small businesses? As part of its statutory mission the U.S. Metric Board has sponsored research projects looking at the implications of metric conversion for the nation's small businesses. This study involves detailed accounts of the conversion experiences of small manufacturers. It follows a more general survey of the metric activity and attitudes in manufacturing, wholesale, retail, transportation, and construction small businesses.

In the first phase of this detailed look at small businesses' experience in converting to metric, the study team contacted 1161 companies to find small businesses making substantial investments in converting to metric. Although only seven substantial investors were found, an interesting portrait of the dynamics and pattern of conversion of small businesses emerged. Central to the portrait was the importance of large businesses to small business conversion to metric. Small businesses convert because their customers ask for metric products. The customers most frequently requesting metric products are large companies.

Observers have speculated, commented, or argued about the interaction of large and small businesses on metric production; little research has been done on the relationship. Case studies fill this need by looking at the costs, benefits, problems, and opportunities for small business in converting in response to large corporations' actions. They also reveal how small business supplier and customer considerations enter into large corporation decisions on metric production.

Do large companies use small companies to produce metric products? Who bears the costs of metric conversion to meet the large companies' needs? Do small businesses convert because of one or several large customers? Do

small companies turn to the large companies for assistance in converting? Who benefits from metric conversion? Who is hurt by conversion? These are the types of questions addressed in these case study reports.

This report covers the metric conversion of the General Electric Company's Data Communications Products Business Department (DCPBD) in Waynesboro, Virginia. It produces high speed data communication printers for use in telecommunications systems, word processors, computers, and other related equipment. Since 1978 it has been making metric products using small business suppliers of metric products.

This case study was done with the active and willing cooperation of General Electric Company and its suppliers. At the Data Communications Products Business Department the staff was open, helpful, and friendly. Mr. Glenn Keller, Manager of Advanced Manufacturing, organized and supervised the study team's visit. Members of DCPBD who generously gave their time to the project include: Bart Conlon, Manager, Mechanical Design Engineering; Harry Quick, lead design draftsman; Bill Wood, Advanced Manufacturing engineer; Ralph Wood, Advanced Manufacturing engineer; Fil Algenbright, Advanced Manufacturing engineer; Kenny Marshall, Supervisor, Quality Control; Hollie McCutcheon, measurement specialist; Ted Crapser, Manager, Standards Engineering; Dick Smith, Manager, Purchasing; Ray Stapleton, Manager, Product Service; Terri Pond, former Buyer, Purchasing; and Jack Steiner, Buyer, Purchasing. Mr. William Kreusi of General Electric Corporate Standards assisted by locating the appropriate G.E. division for study. The study team also owes a debt of gratitude to the many people working for the small businesses supplying Waynesboro who spent time talking about their experience with metric production.

At the U.S. Metric Board, Gene Visco, Ed McEvoy, and Stan Parent were attentive, interested, and involved patrons. At J.F. Coates, Inc., Suzanne Nettles assisted in the contacts with small business suppliers. Bernice Mann, Barbara Bullard, and Rhoda Baum were responsible for the production of the report.

This report was prepared for the U.S. Metric Board uncer Contract Number AA-80-SAC-X8604. Any opinions, findings, conclusions, or recommendations expressed in the report are those of the authors and do not necessarily represent the views of the U.S. Metric Board or the General Electric Company.

CASE STUDY
GENERAL ELECTRIC COMPANY

TABLE OF CONTENTS

EXHIBITS

SUMMARY

General Finding

Suppliers have responded to the conversion of General Electric Company Data Communication Products Business Department's (DCPBD) new line of printers without hardship. The gradual trend toward metric in the electronic equipment industry, the modest size of the DCPBD's orders, and Waynesboro's policy of converting to market available metric products account for the lack of effect on suppliers. Suppliers respond to metric requests as a routine part of doing business with Waynesboro; no suppliers have dropped from DCPBD's supplier list as a result of metric conversion. Most suppliers convert DCPBD's metric requests to customary dimensions for their production; Waynesboro is aware of this and does not care. The quality of suppliers' products remains satisfactory. Metric conversion has fit into established ways Waynesboro deals with its suppliers without incident. On the customer side, it is too early to tell if the DCPBD metric printer will create service problems; it has been on the market for a year. The modular design of the printer will mitigate most problems related to metric.

The Case Study

This general finding and the more detailed findings below come from a case study of the effects of the metric conversion of General Electric Company Data Communications Business Products Department on it suppliers and customers. The purpose of the case study is to look at how small businesses respond to large corporations' metric needs. Previous research shows large customer demands drive most small business conversion to metric.

The study team's research on small business conversion to metric led to several hypotheses about small business-large business interaction on metric. The study team investigated these hypotheses through interviews with the relevant departments within DCPBD, phone contacts with 75 small business suppliers to Waynesboro, and contact with one service firm working on the DCPBD metric printers.

Detailed Findings

From these interviews and phone contacts, the following findings emerged:

- Of the 75 small manufacturers contacted, 45 (60%) supply metric products to Waynesboro. The other 30 (40%) supply parts only in customary dimensions.

- For these 45 small metric manufacturers, the average percent of production devoted to metric is 27%. The median percentage is 25%.

- Small manufacturers producing metric parts for Waynesboro have converted without hardship. They view metric work as a routine part of their business.

- Most companies producing metric products use customary units in production. They consider the time spent converting Waynesboro's metric drawings to customary units trivial; one supplier estimated it takes 15 minutes to convert the average DCPBD drawing.

- Waynesboro's metric suppliers have made insubstantial investments in developing their metric capability. They buy perishable tooling, quality assurance equipment, and digital dual readouts. Only one company spent over $10,000 converting to metric; it did not consider it a substantial investment.

- Unique parts -- stampings, plastic injected molds -- present the most difficulties for suppliers. In a few cases suppliers requested conversion, calibration of inspection equipment, and references to tooling and quality assurance equipment suppliers.

- Metric has no appreciable effect on the quality of suppliers' products. Waynesboro knows their suppliers usually convert their metric drawings to customary units; as long as the quality is satisfactory, they do not care how the part is made.

- Waynesboro's suppliers have not changed as a result of metric conversion. None have been dropped or added. Suppliers and DCPBD say suppliers are too hungry to let the minor inconvenience of metric stand in the way of maintaining or increasing their business.

- Waynesboro does not account for a large percentage of its suppliers' metric production. The average is 13%; the median is 5%.

- Waynesboro's metric conversion is part of a trend in the electronic equipment industry toward metric production. Most of Waynesboro's suppliers also do metric work for other companies in the electronic equipment industry.

When DCPBD first considered conversion, it anticipated difficulties in getting metric supplies from its suppliers. A DCPBD survey of 69 suppliers indicated most were already working in metric. Waynesboro has found no problems in dealing with its suppliers on metric orders. Metric fits comfortably into the established ways Waynesboro deals with its suppliers.

I. INTRODUCTION

Small businesses convert to metric as a result of customer demands. The customers most frequently requesting metric products are large companies, often multinational corporations. This case study involves one of America's best known large corporations, General Electric Company (G.E.). The purpose of the case study is to understand how small businesses affected and were affected by conversion to metric within the General Electric's Data Communications Products Business Department in Waynesboro, Virginia. This section describes how the case study was done, and how the rest of the report is structured.

Why Waynesboro?

General Electric Company is a diverse organization ranging from mining to aerospace. Its facilities are located around the world. In the last decade, metric has been used with greater frequency by divisions within General Electric. When contacted, G.E. said their divisions use small businesses to supply different types of metric products. The G.E. reputation for managerial strength and technological excellence contributed to the interest and the credibility of the case (see background to the case studies for the criteria used to select possible case studies).

William Kreusi, Metric Coordinator for General Electric, told the study team the most appropriate focus for a case study of large business-small business interaction on metric would be a specific G.E. department or strategic business unit. In 1977 General Electric reorganized to form six major industrial groups covering different types of products and services. Under these six major groups are 43 strategic business units. The strategic business unit is a department or group of departments which faces similar market challenges. Most operating and planning decisions are made by strategic business units. They decide whether, when, and how to convert to metric. They are accountable to their industrial group which in turn is accountable to the corporate leadership. The corporate leadership allocates funds for research, administration, capital equipment, management, and other functions on the basis of their performance and prospects.

Different strategic business units and departments in General Electric stand at different stages of metric conversion. The Armaments Department in Burlington, Vermont has developed a prototype weapon for the Department of Defense; production has not begun. The Industrial Compressor Department in Fitchburg, Massachusetts is surveying suppliers to find out if they can and will supply parts for a planned metric compressor. The Television and Headlamp Departments have a small amount of metric activity; it rarely involves outside suppliers. The Data Communications Products Business Department (DCPBD), a strategic business unit under the Technical Systems and Materials Group, has made the most extensive conversion within General Electric.

The Data Communications Products Business Department employs fewer than 1500 people. It is a small department by General Electric standards. Its primary products are data communication printers -- high speed printers used for computers, word processors, and other information technologies. DCPBD also produces miniature and subminiature hermetically sealed electrical relays. Printers and relays are made in three DCPBD plants:

- Metal and Plastic Components - Waynesboro, Virginia
- Electrical Components - Reynosa, Mexico
- Assembly - Waynesboro, Virginia.

The department management offices are also in Waynesboro, Virginia, just across the Blue Ridge Mountains from Charlottesville. DCPBD has been producing printers since 1969. Last year they produced 40,000 printers. Their total sales for last year exceeded $100 million.

In 1978 the manager of DCPBD, in consultation with the staff, decided to convert all new production to metric. One reason given was that a significant portion of their business, 25-30%, is with European Economic Community. The conversion began with prototype work on the first new project after the 1978 decision -- the Terminet 8000, a very high-speed printer. This printer remains in the prototype stage at present. Waynesboro's first metric product was the Terminet 2000 series of printers -- low cost, compact, high speed printers (see Exhibit 1). Since its introduction in mid-1980, Terminet 2000 series has become DCPBD's largest selling line with 10,000-15,000 printers

Exhibit 1

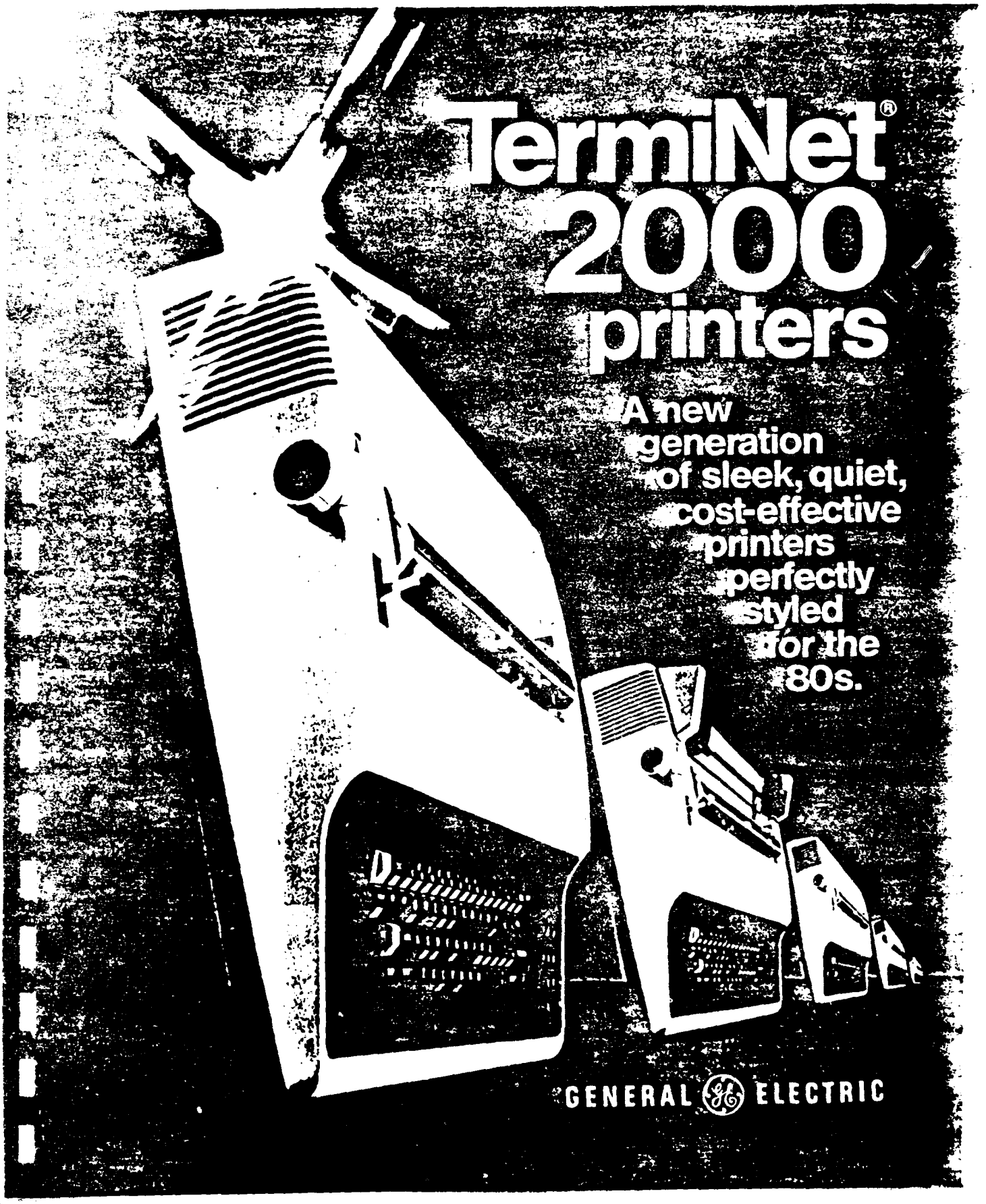
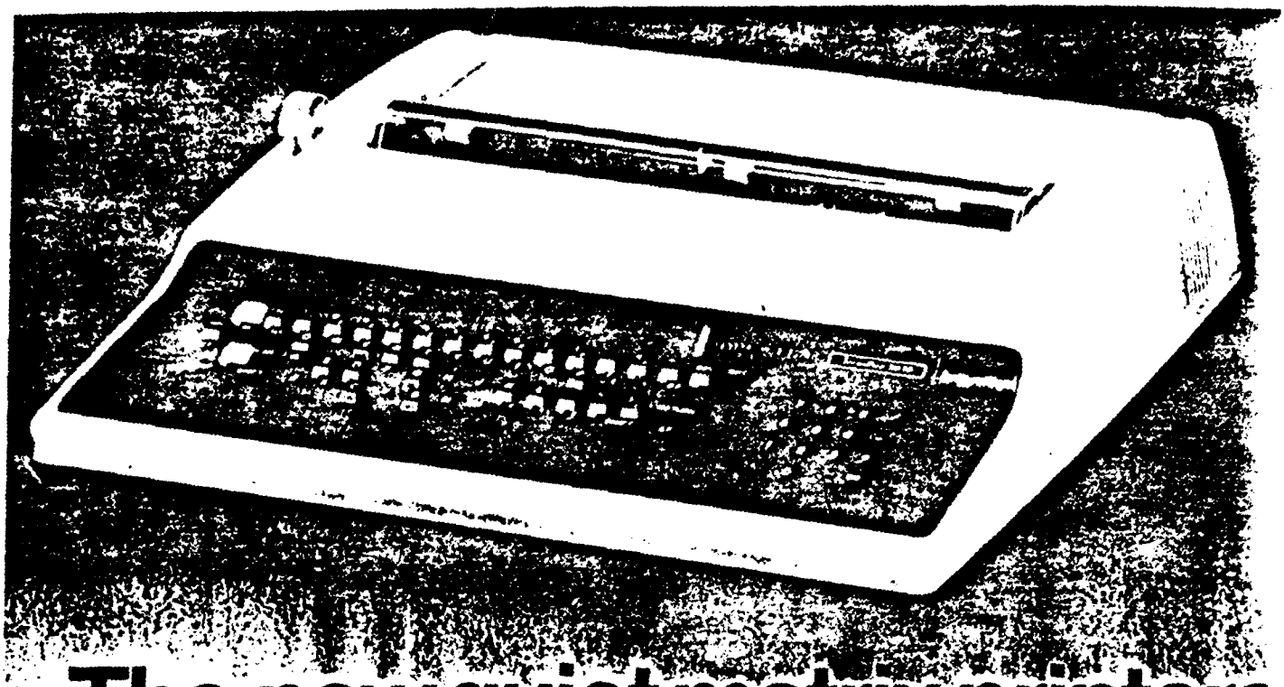

TermiNet®
2000
printers
A new generation of sleek, quiet, cost-effective printers perfectly styled for the 80s.
GENERAL ELECTRIC

Exhibit 1, continued.



The new quiet matrix printers

Now there's a new generation of fully featured matrix printers designed especially for the data processing needs of businesses in the 80s. The TermiNet® 2000 printers from General Electric.

New stylistic and functional features are designed into TermiNet 2000 printers to provide outstanding performance in a variety of applications and operating environments.

The TermiNet 2030 printer

The TermiNet 2030 KSR and RO 30-cps printers are the first of a new series. Packed with features, the TermiNet 2030 printer is easy to operate and combines high performance with low cost of ownership.

Like all TermiNet 2000 printers, the TermiNet 2030 is designed to look sleeker, run quieter, use less power, and take up less space. And it offers a number of features such as a non-volatile configuration memory that saves considerable operator and programming time.

And of course, the TermiNet 2030 is backed by a wide range of technical support programs to help increase operator efficiency. These include complete documentation, training, and worldwide General Electric service.

Sleek, streamlined and quiet

Take a good look at the sleek, streamlined TermiNet 2030 printers. Their highly stylized design fits any office decor. Then listen carefully. Chances are you'll like what you hear. That's because, the TermiNet 2030 printer is quiet. And with a smaller printhead than comparable printers, it's also compact.

In addition, fewer parts and injection-molded enclosures result in lightweight units. So maintenance is simplified and reliability increased.

Easy to use

Updated styling isn't the only improvement you'll find in the TermiNet 2030 printer. A number of functional improvements have been built in to simplify operation. All designed to make TermiNet printers the perfect fit for virtually any application.

A new stationary cartridge with mobius-loop ribbon provides three million characters between changes. The ribbon system also snaps in quickly for clean, easy changes. The servo-driven printhead permits bi-directional printing without the need for fill characters, and features true underline capability plus highly legible descenders.

Paper handling is easier, too, with a standard friction-feed platen to accommodate either single-sheet or roll paper. Use the top paper feed path for single sheet forms. Up to three part forms are handled through the bottom paper path. Optional tractors are also available to guide various widths of pin-feed paper. In addition, there's a standard adjustment knob for manual paper spacing.

Plus, fully annotated TermiNet keyboards feature capacitive key switches that are inherently reliable and simplify repair. Both the domestic and international models are ANSI-typewriter paired. Kits are available for conversion into popular national character sets.

®Registered Trademark of General Electric Company

Exhibit 1, continued.

t'hat deliver high performance

Blade matrix printhead—the leading edge of printhead technology

The key to the TermiNet 2030 printer's dramatic improvement in acoustic performance, streamlined profile and reliability is the blade matrix printhead, developed and patented by General Electric.

Powerful samarian-cobalt permanent magnets combine with revolutionary blade coil/frame assemblies to create an electromagnetic force field which actuates the proper print pin.

Weighing just over four ounces, the blade-matrix printhead is a real heavyweight in printing performance.

Improved electronics for improved performance

Dual microprocessors provide speed, flexibility, and reliability. A custom LSI servo-control chip and RS232C data interface also provide reliable and accurate operation.

TermiNet 2030 printers feature an easy-to-read digital display for print position indication, configuration display and test/diagnostic read-out.

And, a small, lighweight, energy-efficient power supply is achieved by using switching-type regulators.

More options for more flexibility

A variety of options add even more capabilities to TermiNet 2030 printers. These include a 16K line buffer, a 32K text editor, current interface, an FCC-certified 300 baud modem, and dual tractors for accurate forms control. Plus, a numeric cluster provides the KSR with quick, efficient entry of numerical data. A data set cable and paper roll holder are also available. Other options are listed in the specifications.

Complete service with excellent technical support programs

Overall, TermiNet 2000 printers are designed to run with minimal problems. However, if something should go wrong, a range of technical support programs is available to keep the printers on-line.

Each TermiNet 2000 printer features a self-test capability that helps identify and locate problems. In addition, partitioned electronics simplify both diagnostics and repair.

Complete engineering backup, including detailed documentation, is available, as well as training programs that show operators how to use their new printers efficiently and productively. Service training for OEM personnel is available where applicable.

See for yourself

If your're looking for stylish, quiet, rugged, high-performance matrix printers, look no further than TermiNet 2000 printers. They're the ones built for the business data processing needs of the 80s. For more details, write to the address on the back cover.

Exhibit 1, continued. General Electric

TermiNet 2030 Printer Specifications

CONFIGURATIONS
KSR: Keyboard send receive
RO: Receive only

DATA TRANSMISSION
Code: USASCII/ISO (7 bits plus parity)
Interface: EIA RS-232/V.24
Speed: 110/300/1200 bits per sec.
Type: Asynchronous, 10 bits per char. (110 bits per sec.)
Mode: Half/full duplex▼
Parity: Odd/even/mark/space▼
Answerback: Up to 20 characters

PRINTING
Type: Matrix impact
Speed: 300 char. per sec.
330 char. per sec. (catch up)
Technique: Bi-directional, logic seeking
Head: Blade, 9 wire
Font: 94 graphics (ASCII/ISO), £ and ¤
substitution▼
Character Formation: 9 high x 7 wide, includes lower case descenders and underline
Character Spacing: 10/13.2/16.5 per inch▼
Line Spacing: 3/3/4/6/8/12 per inch▼
Print Line: 13.2 inches
Buffer: 288 characters
Ribbon: Fixed cartridge, 3 million characters
Test: Built-in logic and print test

PRINT CONTROL
Margins: Left and right any position▼
Horizontal Tabs: Any position up to 20▼
Top of Form: Any form length up to 20 inches▼
Vertical Tabs: Any position up to 20▼
Bottom of Form: Any position provides auto-perforation step-over▼
Backspace: Permits overstrike and underlining
Auto CR LF: Avoids loss of received data

PAPER HANDLING
Friction Drive: Top feed–single sheet or single part roll paper
Tractor Drive: Top feed–single part or bottom feed–1, 2, or 3 part
Paper Width: 75 to 390mm (2.95 to 15.35 in.)

KEYBOARD (KSR)
Type: Stackhanded, N-Key rollover
Layout: ANSI typewriter paired
Code Generation: Up to 128 combinations
Keytops: Color coded and annotated

FUNCTIONS AND STRAPS
Operator Selectable: By Function (FCT) Key
Remotely Selectable: By Escape (ESC) Sequences
Retention: By battery supported memory (multi-year life)

INFORMATION DISPLAY
Displays: Current print position
Status of functions and straps
Diagnostic results and alarms

PHYSICAL
Size: 560 w x 470 d x 140 h mm (22 w x 18.5d x 5.5h inches)
Weight: 10 kg (22 lbs)

ELECTRICAL
Domestic Model: 99-129 VAC, 48-65 Hz
International Model: 198-264 VAC, 48-65 Hz
Power: 300 watts

OPERATING ENVIRONMENT
Temperature: +4° to +40° C (+40° to +105°F)
Humidity: 5 to 95% relative

OPTIONS
Data set cable
Numeric cluster
Tractor
Paper roll holder
20mA current interface
Dual font
Text editor, 32K characters with battery back-up
Internal type 103 modem
Line buffer, 16K characters
Pedestal
International keyboard/character kits

▼▼ –Selectable by operator and by remote command

TermiNet printers are available worldwide from General Electric Company USA affiliates and from a network of authorized distributors.

For more information contact:
In the U.S.A., your local GE Data Communications Business Department Sales Office;
In Canada, Canadian General Electric Co. Ltd, 396 Attwell Drive, Rexdale, Ontario, Canada M9W5C3;
And worldwide, In Australia—Melbourne (13) 233-7711;
In Canada—Toronto (416) 675-7500
In France—Paris (01) 723-5594;
In Germany—Frankfurt (06196) 48501;
In Sweden—Stockholm (08) 730-0740;
In the United Kingdom—London (01) 402-4100

Or contact Internal Sales, Data Communications Products Business Department, General Electric Company, Waynesboro, VA 22980 U.S.A.

General Electric Company
Data Communications Products Business Department
Waynesboro, VA 22980
(703) 949-1000

GENERAL ELECTRIC

per year being made. These printers sell for between $800 and $3,000.

DCPBD is well suited for a case study. Conversion is recent, enabling the study team to uncover how considerations of suppliers and customers entered into the conversion decisions. Also suppliers were able to recall the effects of Waynesboro's conversion. DCPBD uses suppliers for the numerous parts and sub-assemblies used in the printers (see Exhibit 2).

How the Case Study was Done

The study team selected Waynesboro after talking with several departments within General Electric. They had completed a conversion -- the Terminet 2000 series of printers -- and use small businesses to supply parts for this product. With the concurrence of the General Electric Metric Coordinator, the study team contacted DCPBD management, described the project, and got their approval and cooperation.

The first step of the case study involved interviews with the relevant DCPBD departments:

- Engineering
- Engineering Standards
- Advanced Manufacturing
  -- Quality Assurance
- Purchasing
- Product Service.

In these interviews the study team focused on conversion of:

- Prototypes
- Parts for Production
- Production Equipment
- Product Service.

In exploring each type of conversion, the key considerations were:

Exhibit 2

COMMODITIES SUPPLIED TO DCPBD

COMMODITY	COMMODITY
ADHESIVES	NAMEPLATES
BATTERIES	OFFICE EQUIP/SUPPLIES
BEARINGS	PACKAGING MATERIALS
BELTS	PAINTS
BLOWERS	PAPER PRODUCTS
CABLE	PIPE FITTINGS
CAPACITORS	PLASTIC, ALL
CAPITAL EQUIPMENT	PLUMBING SUPPLIES
CARBON PRODUCTS	POWER SUPPLIES
CASTINGS	PRINTED CIRCUIT BOARDS
CHEMICALS	PRINTING SUPPLIES
CLUTCHES	RAW MATERIAL
COILS	RELAYS, SOLENOIDS
CONNECTORS, CONTACTS PLUGS	RESISTORS
CRYSTALS	RUBBER PARTS
ENGINEERING SUPPLIES	SAFETY EQUIPMENT
PLANT EQUIPMENT	SEMICONDUCTORS
FABRICATED PARTS	SERVICE CONTRACTS
FANS	SHOP SUPPLIES
FIBRE	SLEEVING
FUSES	SOCKETS, TUBES
GAUGES	SOLDER
GASKETS	SPRINGS
GEARS	STAMPING
GLASS PRODUCTS	SUBCONTRACTING
HARDWARE	SWITCHES
HOUSEHOLD MOVES	TAPES
INTEGRATED CIRCUITS	TAPE READERS, PUNCHES
LAMPS	TERMINALS
LUBRICANTS, OILS	TERMINAL BOARDS
MACHINED PARTS	THERMOSTATS
MAG TAPE	TOOLS
MAGNETS	TRANSISTORS
MAINTENANCE & REPAIR	TRANSFORMERS
MOTORS	TUBES, ELECTRONIC
	VARISTORS
	WIRE

- How has the conversion affected small suppliers and customers?
- How did considerations of small suppliers and customers affect the extent, timing, cost, and overall conversion experience within DCPBD?

From discussions with purchasing, the study team got a list of suppliers to Waynesboro. Originally a list of vacation shutdown times for Waynesboro's major suppliers (149 companies), this list has several important features:

- It was not developed for the purpose of this study;
- It covers the range of products supplied to DCPBD;
- It has the suppliers doing the most work for DCPBD.

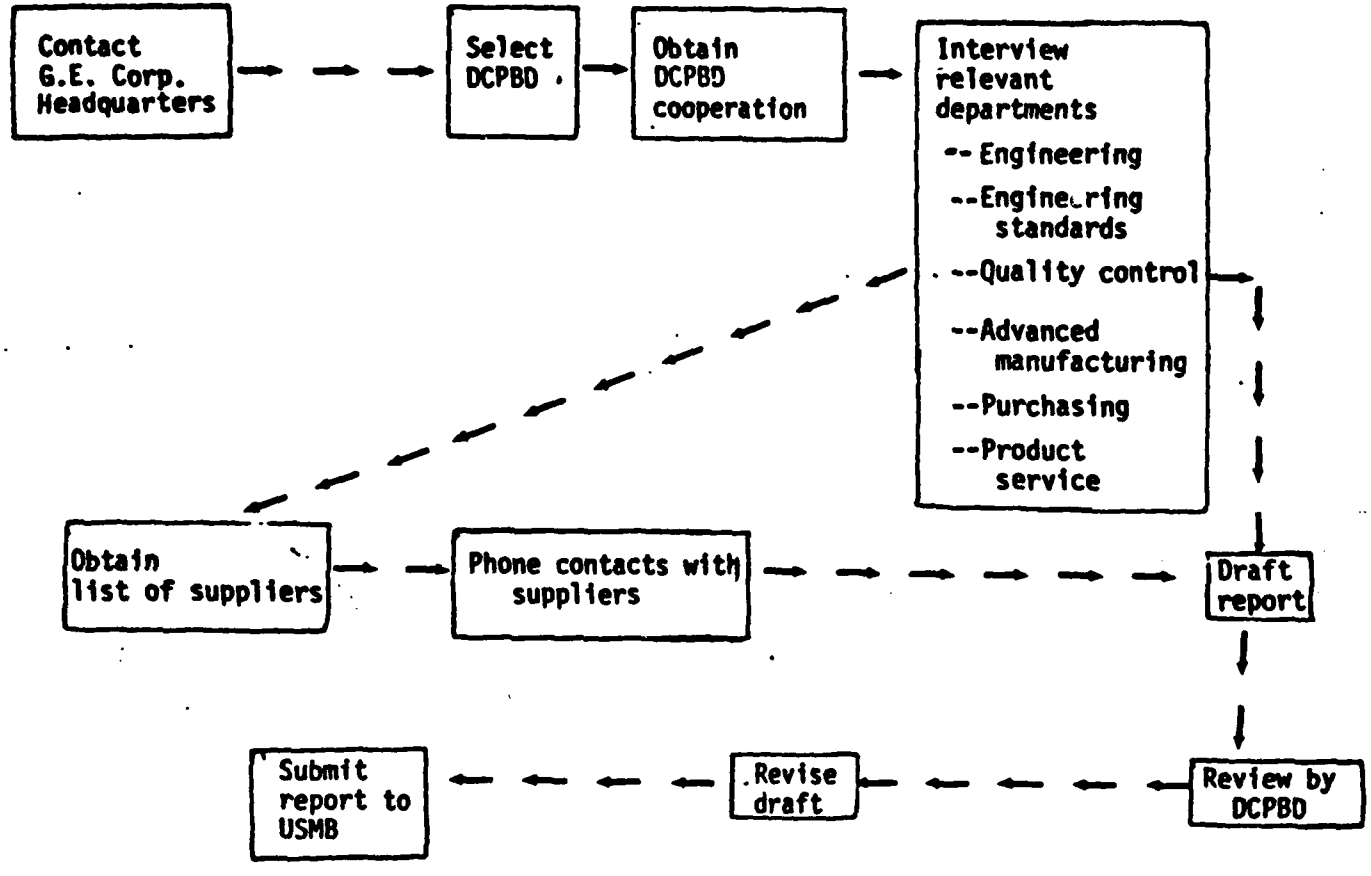
The study team asked the small companies on the list (independent businesses with fewer than 500 employees) about their metric conversion -- the costs, benefits, problems, and opportunities they faced. In these initial phone contacts, the team was looking for small companies making substantial investments in metric conversion.

None of the companies contacted said they made a substantial investment converting to metric. As a result, detailed follow-up visits were not required. A Draft Report was prepared on the basis of the interviews with DCPBD staff and the phone contacts with suppliers. This draft was reviewed by DCPBD and revised by the study team. Exhibit 3 summarizes the steps in the DCPBD case study.

The study team did not focus on service organizations working on General Electric printers. Discussions with DCPBD indicated:

- Most of the printers were bought and serviced at large office equipment manufacturing firms;
- The only small businesses they were aware of working on the metric printers were those affiliated with G.E. service centers;

EXHIBIT 3: DCPBD CASE STUDY FLOW



What Follows

The case study report's two sections discuss:

- The implications of supplier considerations for the DCPBD's conversion, and
- The effect of DCPBD's conversion on its suppliers.

The next section describes how metric conversion fit into the established pattern of relations between Waynesboro and its suppliers. The final section discusses effects of Waynesboro on its suppliers including Waynesboro's perception of the effects and the suppliers' own reports.

II. METRIC CONVERSION AND WAYNESBORO'S RELATIONS WITH SUPPLIERS

Introduction

The case study of Waynesboro's conversion to metric follows two paths -- the effects of conversion on suppliers and the effects on how DCPBD relates to its suppliers. Relations with suppliers refers to:

- The ways suppliers are involved in internal DCPBD design decisions;
- The effect of customers' concerns on engineering;
- The perceptions of suppliers' capabilities and the effects of those perceptions on design and production;
- The relative roles of purchasing, advanced manufacturing, and engineering departments in dealing with suppliers;
- The primary considerations each department brings to bear in its dealings with suppliers

To uncover how metric conversion affected relations between DCPBD and its suppliers, the study team developed an overview of the normal way a product moves from concept to production to service and repair. Against this background, the team looked for changes in the type and nature of dealings with suppliers as a result of metric conversion.

The case study found no change in the way DCPBD deals with its suppliers as a result of metric conversion. Metric fit comfortably into established practice. This chapter amplifies this central theme.

Suppliers and the Product Lifecycle

Suppliers are involved in many phases of the design, production, and servicing of DCPBD's products. Each step in the movement from concept to product involves different DCPBD departments, different suppliers, and different key considerations in the relations between DCPBD and suppliers. These differences are important to understanding how metric conversion affects the way DCPBD looks at and deals with its suppliers.

Four stages in the movement from concept to product service involve suppliers.

- Prototypes - To prove a concept and improve design, DCPBD engineering department builds prototypes of final products. Some parts must be supplied by outside suppliers for these prototypes.
- Parts for Production - When a product is being made, some parts are made by outside suppliers. Some parts are standard items such as nuts and bolts; others are unique or custom parts designed for that product, such as plastic covers or metal brackets for holding equipment.
- Production Equipment - To make a product, new machines or new capabilities for existing machines may be necessary. DCPBD may purchase these machines or capabilities from outside suppliers.
- Product Service - After the product leaves DCPBD, customers or service companies modify or repair DCPBD products. DCPBD design and production must therefore keep customer and service needs in mind.

In each of these stages different departments take the lead in dealing with suppliers.

The departments in DCPBD which deal with suppliers are:

- Engineering designs and develops prototypes of products. Their drawings are used by DCPBD and its suppliers to produce the product.*
- Engineering Standards reviews engineering drawings and develops drawings for purchasing standard parts. They also approve suppliers of standard parts.

---

* These brief descriptions only refer to those activities of these departments of direct relevance to supplier relations.

- Advanced Manufacturing is responsible for planning all internal production. They determine if a product can be made internally or must go to outside suppliers; they also identify the need for new capabilities or new machines for in-house production.
- Purchasing identifies, selects, and orders from suppliers. They have the most contact with suppliers.
- Quality Control checks the in-house and supplier products against engineering specifications.
- Product Service maintains the network of service organizations, trains service personnel, and works to ensure serviceability is integrated in design.

The following sections describe how metric fits comfortably into the patterns of relations between Waynesboro and its suppliers. These descriptions cover the product lifecycle from prototype to product service -- a lifecycle involving over 1000 G.E. employees at three factories, hundreds of suppliers, and from several years to decades depending on the lifetime of the product.

Prototype

The development of a new product involves research, engineering, and design. Once the concept has been approved, work begins on a prototype of the product. Waynesboro's metric conversion began with development of a prototype of the Terminet 8000 printer. The metric Terminet 2000 printer also began with the development of a prototype. On the basis of a prototype, final engineering drawings are developed and sent to advanced manufacturing and engineering standards for production.

In building prototypes, Engineering works directly with suppliers to get parts for their prototypes. These parts can be standard items such as nuts, bolts, hinges, or custom items such as metric stampings or molded plastic parts. Engineering needs relatively few parts for making prototypes so their orders are small. When Engineering needs a part they scan catalogs or go to known suppliers for a few parts. The suppliers deliver products directly to Engineering.

The Engineering department also works with suppliers to outfit its engineering model shop with new machines or new capabilities. Again, the engineers search the catalogs and known suppliers for sources of equipment for the model shop and buy directly from them. Exhibit 4 summarizes the relation with suppliers in prototype development. Note that the only DCPBD department involved is Engineering.

In purchasing parts for the prototype and equipment for the model shop, engineering is primarily concerned with the availability of parts in the right configuration -- dimensions, materials, volume -- for their prototype building. However, they must also be sure the parts will be available in sufficient quantities for production of the product.

Engineering has had no continuing problems with getting metric products or equipment. At first, conversion to metric increased the time involved in developing the prototype. Metric parts were harder to find and took longer to get than customary parts. G.E. corporate metric standards had not been established; this also increased the design time. Metric parts cost more at first. These problems have disappeared as Engineering has become more familiar with purchasing metric supplies and making metric products.

Parts for Production

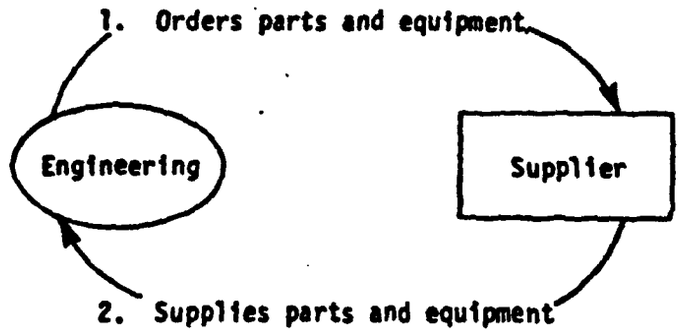
When design has been completed and production approved, procurement of parts to be included in the product begins. The first distinction is whether the part is standard or unique. A standard part is one which can be ordered directly from a catalog -- screws, wrenches, rings, seals, bolts, washers, shafts, etc. A unique part is one that is special to the product -- the chassis for the printer, the side plates, the plastic molded covering for the printer, the print heads, etc. Relations with suppliers differ for these different types of parts.

Standard Parts

Buying a standard part such as a bolt begins with the drawings of the Engineering department. The drawings of the bolt are sent to the Engineering Standards department. The Engineering Standards department reviews

EXHIBIT 4

PROTOTYPE PARTS



the drawings, consults catalogs, consults vendors, and develops a "purchased part drawing" of the bolt. This drawing is used as the basis for purchasing the product. For common products, G.E. corporate standard purchased part drawings are used. The Engineering Standards department also identifies suitable suppliers for the bolt; sometimes these are suppliers identified by Engineering in the prototype development.

The purchased part drawing and the list of approved suppliers for the bolt are sent to the Purchasing department. Purchasing may review the drawing and the list of suppliers and go back to Engineering Standards with names of additional suppliers. Engineering Standards approves or disapproves the addition of the bolt suppliers suggested by Purchasing.

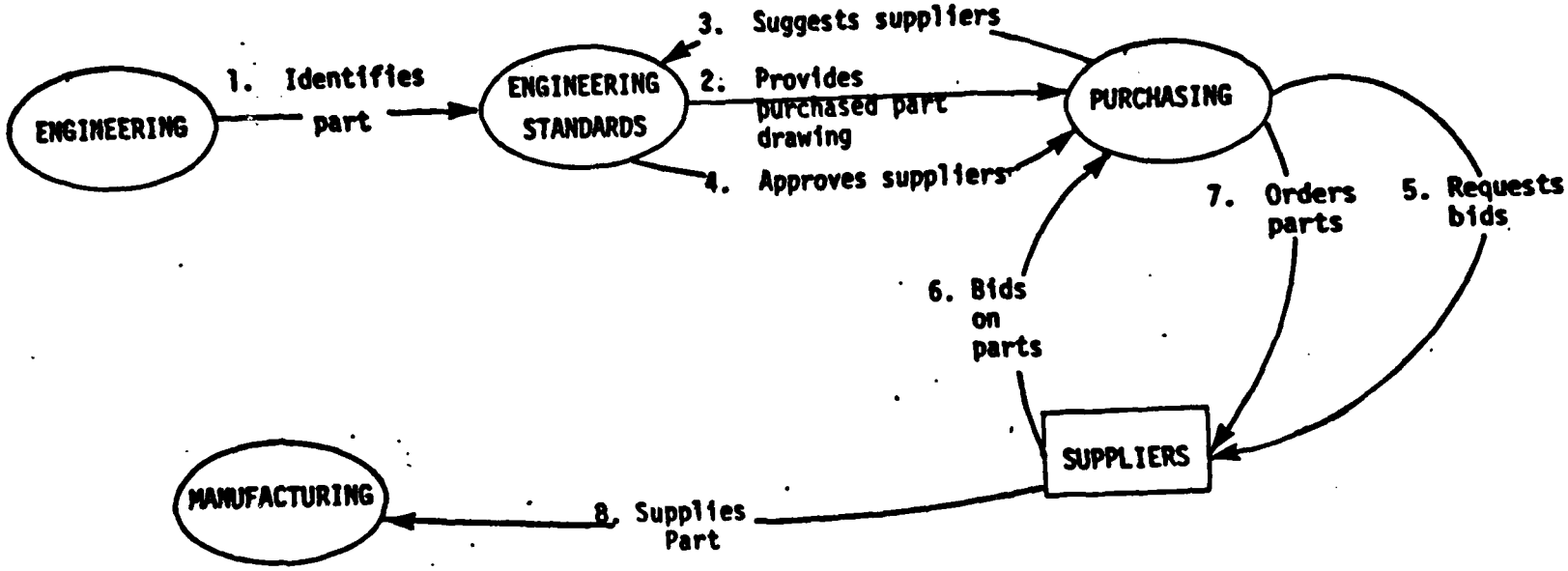
When the list of suppliers has been agreed upon, Purchasing sends out a request for bids on the bolts to the supplier companies. These requests specify the dimensions for the bolt, the tolerances, the quantity desired, and the delivery date. The suppliers respond with estimated costs of producing and delivering the product. On the basis of these estimates, Purchasing selects a supplier. The selection is based on price, delivery, and service (willingness to stand behind the product). Purchasing orders the bolts from the selected supplier. The supplier produces the bolts and supplies them to the Waynesboro plant at the specified time. Exhibit 5 summarizes the steps involved in buying standard parts.

In approving suppliers of standard parts, Engineering Standards primarily looks at availability and quality. They monitor the trade press, talk to sales representatives, and review company catalogs to keep abreast of the market. They also use standard catalog search services when looking for new parts. Cost, delivery, and service are most important to Purchasing. They look for ways to lower costs and improve delivery performance. For this reason, they try to find suppliers to add to the Engineering Standards approved list.

Waynesboro buys standard metric parts the same way they buy conventional standard parts. The metric hardware they use is easily available at competitive prices. Waynesboro gets most of its metric hardware from medium or large companies.

Exhibit 5

STANDARD PARTS



There have been a few minor problems such as firms stating they stock metric parts when, in fact, they will produce the parts on special order. This is also true of special customary products. There have been problems with metric hardware which is not completely metric -- for example, a metric bracket had a customary center hole which did not mate with a metric diameter shaft. Problems with standard metric parts have decreased in the three years Waynesboro has been working in metric. For example, three years ago, they had problems finding metric timing belts. Now, two major rubber companies have come out with metric timing belts.

Unique Parts

A unique part is a part designed by Waynesboro's Engineering department for a specific product. These could be metal brackets or plastic injection molded covers for the printer. The key point about these products is they are not standard -- they are custom. As custom parts they require close attention to make sure they meet design specifications. Also, as custom parts they mean more involvement of suppliers with the end product. In standard parts, DCPBD is buying the same product many other companies are buying. In unique parts, the supplier is making the product for DCPBD to DCPBD's specifications

For a unique part such as a bracket, drawings go from Engineering to Advanced Manufacturing. Advanced Manufacturing is responsible for planning and equipping the DCPBD production line. They decide whether the bracket should be made in-house or sent to an outside supplier. This "make or buy" decision is based on:

- current and projected in-house production capacity -- DCPBD may not have the machines available to make the bracket in time
- cost of tooling -- in-house and supplier -- a supplier may be able to make the part with cheap disposable tooling; DCPBD would use more costly durable tooling.
- quantity desired -- suppliers often make smaller quantities for less cost than DCPBD could.
- supplier's price.
- lead time until needed -- suppliers can often make the brackets sooner than DCPBD; one of a supplier's selling points is responsiveness.

- need for tooling in the future -- DCPBD may make the bracket in-house if they see a continuing demand for the product.

There are five operations involved in making unique parts for DCPBD's products. The balance between in-house and outside supply differs depending on the process involved.

- stamping -- usually done outside
- turning -- most in-house
- machining -- most in-house
- processing/treatment -- balance between in-house and outside
- plastic molding -- balance between in-house and outside

At present, the balance is 50% in-house production vs. 50% supplier production. DCPBD prefers in-house production to supplier production because in the long run it is cheaper, more reliable in scheduling, and makes the best use of in-house production capacity.

If Advanced Manufacturing decides to produce the bracket in-house, the drawing goes directly to Manufacturing for production. Otherwise, they purchase the part from a supplier. DCPBD buys unique parts from suppliers in two ways. Waynesboro can buy a limited amount of a product from a supplier; this is usually to meet an immediate need while maintaining the option of producing the product in-house. Or DCPBD can buy a complete production run from a supplier, pay for the tooling, and possibly bring the tooling in-house for possible future production. (See below for more discussion of tooling costs.)

If the metal bracket is to be supplied by an outside company, advanced manufacturing sends part drawings to purchasing. As in the case of standards parts, purchasing sends the drawings to a list of suppliers and requests bids. The list of bidders is based on past experience with production, past bids, expressed interest, potential cost savings, ability to deliver on time, and reputation for servicing products. Exhibit 6 is the DCPBD instruction sheet to visiting suppliers. The Purchasing department tries to involve as many suppliers as possible in this process to increase the chances of getting lower bids on the product.

The suppliers send estimates of the costs for producing the metal bracket back to Purchasing. These estimates include tooling costs and

Exhibit 6

TermiNet® DATA COMMUNICATION PRODUCTS

WELCOME TO GENERAL ELECTRIC'S DATA COMMUNICATION PRODUCTS BUSINESS DEPARTMENT. PRODUCTS MANUFACTURED AT THIS LOCATION INCLUDE DATA COMMUNICATION PRINTERS, MINIATURE AND SUBMINIATURE HERMETICALLY SEALED RELAYS.

OUR PURCHASES ARE BASED ON TOTAL VALUE BASED ON PRICE, QUALITY AND SERVICE. WE INVITE YOUR COMMENTS AND SUGGESTIONS FOR IMPROVING VALUE AND REDUCING COSTS.

WE REALIZE THAT YOUR TIME IS VALUABLE AND, THEREFORE, ASK THAT YOU BE BRIEF AND TO THE POINT DURING YOUR VISIT. APPOINTMENTS, WHILE NOT MANDATORY ON TUESDAY THROUGH WEDNESDAY, ARE ENCOURAGED FOR ALL VISITS.

PURCHASING/VENDOR VISITING HOURS ARE:

MONDAY	- BY APPOINTMENT
TUESDAY-THURSDAY	- 9:00 AM - 3:00 PM
FRIDAY	- BY APPOINTMENT

SHOULD YOU WISH TO VISIT NON-PURCHASING PERSONNEL, IT IS REQUIRED THAT YOU CONTACT THE BUYER HAVING PROCUREMENT RESPONSIBILITY PRIOR TO YOUR NON-PURCHASING VISIT.

THANK YOU FOR YOUR INTEREST IN GENERAL ELECTRIC PRODUCTS. WE HOPE YOUR VISIT WILL BE REWARDING TO BOTH YOU AND GENERAL ELECTRIC.

R. R. SMITH
MANAGER-PURCHASING
(703) 949-1414

GENERAL ELECTRIC

piece costs. Tooling costs are what it costs to make the dies, molds, or castings used to produce the part. There are different qualities of tooling; "quick and dirty" tooling is inexpensive and lasts for a limited number of parts. Durable tooling is more expensive but lasts over many production runs. For example, a "quick and dirty" tool for a short run stamping of a metal bracket might cost as little as $250, if supplied by a firm specializing in such work. A tool designed to produce the metal brackets for a long period of in-house production may cost as much as $4,000.

Piece costs are the costs to produce each piece. Piece costs including 10,000 brackets might be $1.00 per piece. Piece costs include materials costs, labor costs, capital equipment costs, and profit. If tooling costs are low or if the tooling is to be owned by the supplier, tooling costs are included in piece price. If the tooling costs are substantial and Waynesboro wants to own the tooling, tooling costs are paid separately. Waynesboro often chooses to pay tooling costs because it increased their flexibility. If a supplier goes on strike or fails financially, DCPBD can give the tooling to another supplier to produce the product. Also, if Waynesboro owns the tooling, it can bring the production in-house in the future.

Purchasing selects a supplier for the bracket on the basis of cost, delivery, and service. Samples of the bracket are ordered from the selected supplier. The supplier provides the sample brackets to the Quality Control department. Quality Control puts the bracket through detailed analyses to see if it meets Engineering's specification. On the basis of these tests, they accept or reject the bracket. A report on the part, stating the judgment of the Quality Assurance department on the bracket is forwarded to Purchasing.

Most parts supplied to Waynesboro by suppliers are used. However, as many as 70% may be rejected by Quality Control. The reason for the high rejection rate is the very close tolerances on the Engineering drawings. In most cases, the part can be used even though it exceeds the tolerances.

After the bracket is accepted by DCPBD, Purchasing orders a full run from the supplier. The supplier produces the brackets and supplies them to Manufacturing.

Exhibit 7 summarizes the steps in buying unique parts for production. Key differences between buying unique parts and buying standard parts are:

a) a decision by advanced manufacturing whether to make the part in-house or purchase it from a supplier, and

b) the review of samples by Quality Control.

The key factors involved in the purchasing decision are the same -- cost, quality, availability, service. However, in the unique parts area, different suppliers are chosen to maximize different factors; for example:

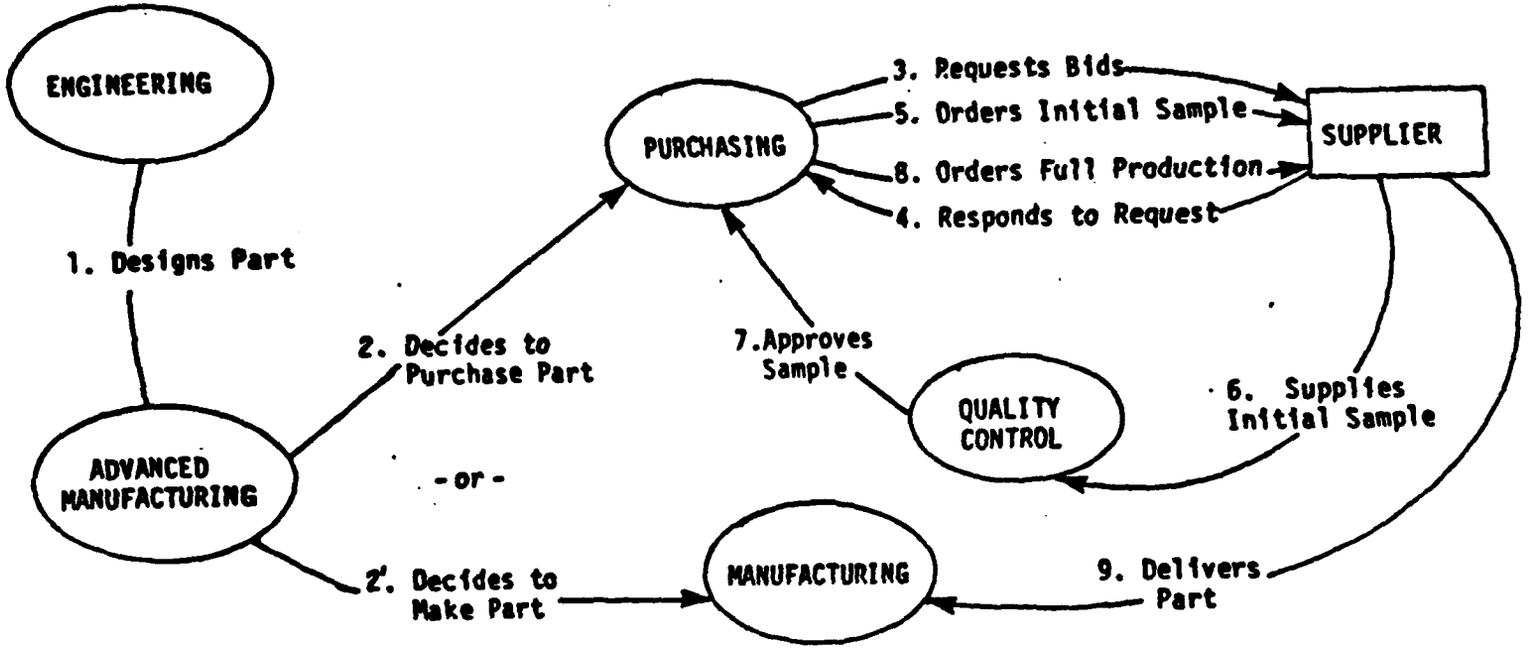
- short run stamping shops for cost of tooling;
- local machine shops for short lead times;
- in-house production for future tooling needs.

Metric conversion has had its greatest impact on the supply of unique parts, according to DCPBD staff. There has been a small increase in lead times for metric products relative to similar customary products. Suppliers have had problems getting metric tooling for their production at economical prices. There have also been requests for assistance by suppliers, such as:

- Advice on metric quality control equipment - Some suppliers do not have metric inspection equipment. A few (3-4%) have asked purchasing where DCPBD gets its metric inspection equipment.
- Calibrating quality control equipment - In a few cases (3-4%) suppliers send their inspection equipment to Waynesboro to be calibrated against DCPBD's equipment. They do this to improve their ability to meet DCPBD's specifications.
- Providing tooling - In a few instances DCPBD provides suppliers with the tools, molds, or dies for making metric products for DCPBD's uses. They do the same for customary products. This is usually done with local suppliers -- such as machine shops -- when there is an immediate need and no in-house capacity for producing the item.

Exhibit 7

UNIQUE PARTS



DCPBD has not offered or been asked to offer metric training for its suppliers. The closest to such an arrangement was when the owner of a local machine shop attended an in-house G.E. course on the geo-metric drawing system.

While there have been a few more difficulties with unique parts, it has not affected quality of the suppliers' products. Rejection rates have not increased as a result of metric conversion.

Production Equipment

Waynesboro also buys tools, machines, or hardware for production -- milling machines, reamers, screw machines, lathes, taps, dies, molds, etc. When Advanced Manufacturing decides to make a unique product in house, they determine if they need additional production equipment. If they do, they can make their own equipment or purchase equipment. To purchase a milling machine, for example, Advanced Manufacturing supplies specifications to Purchasing. Purchasing selects a supplier and orders the machine. Exhibit 8 shows the steps to purchasing production equipment. The supplier produces the machine and supplies it to the plant. As with other products, the primary considerations are cost, delivery, service, and quality.

Three years ago Advanced Manufacturing estimated a cost of $44,220 for converting plant equipment to be able to produce the metric Terminet 2000 series of printers. Most of this cost was digital dual readouts for lathes and milling machines. The rest was for additional tools and quality control equipment. Exhibit 9 shows DCPBD's estimated costs of converting the Waynesboro plant in terms of investments and one-time expenses, such as labor for instruction. The actual costs of equipment conversion were slightly less than estimated. In equipping the plant for metric production DCPBD used their usual machinery suppliers; many firms offer digital dual readouts.

According to DCPBD staff, a major benefit from converting the machinery to a dual measurement capability has been a rejuvenation of older machines. The digital readouts have improved the accuracy of the older lathes and milling machines. On the other hand, there has been a 1-2% increase in the scrap rate on the metric screw machines. One cause for this may be workers' unfamiliarity with metric thread sizes.

Exhibit 8

PRODUCTION EQUIPMENT

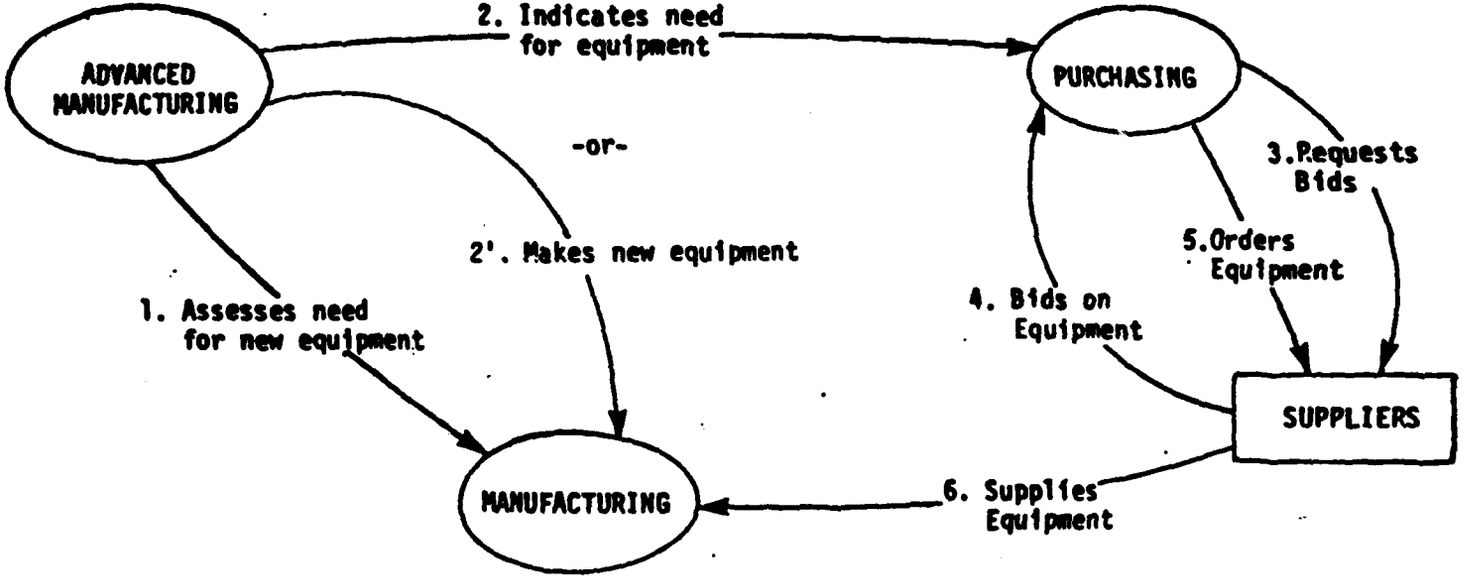


Exhibit 9

EQUIPMENT METRIC CONVERSIONS

	INVESTMENT	EXPENSE
Metal Parts Fabrication		
2 Bridgeport Vertical Milling Machines 2 Hardinge Lathes 1 Warner & Swasey Lathe 1 Gallic Lathe 1 Logan Lathe 1 Strippit Fabricator	$	$
Sub-Total - 8 Machines	$17,000	1,000
1 Hurco Inch-Metric Switchable Back Gage with Expanded Memory For Press Brake	8,500	500
3 Unidentified Future Conversions 3 @ $2,000 Est.	6,000	500
Tool Room Equipment		
Digital 24" Height Gage Inch/Metric Switchable	3,000	200
Quality Control Equipment		
Metal Parts Inspection Chordax Conversion	2,000	-
Process Control Lab - Gear Checker Adapter	1,500	-
	36,000	2,200
Contingencies @ 10%	3,800	220
Total	$41,800	$2.420

Product Service

The customers for Waynesboro's printers are outside equipment manufacturing firms. These firms make the G.E. printer part of an overall office system such as a word processor or a computer system. In a few cases printers are sold directly to the people who will use them.

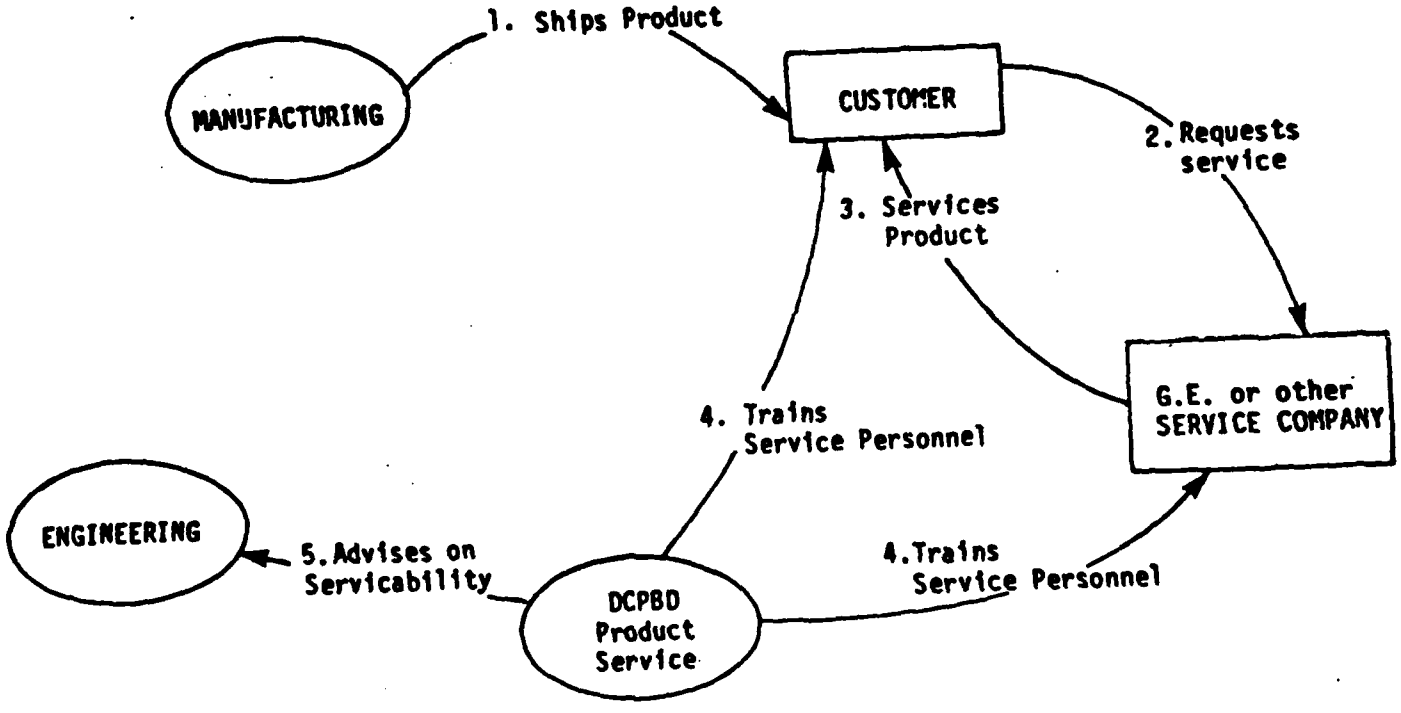
Equipment is serviced by three types of organizations: General Electric service offices or their sub-contractors, the customers (usually the outside equipment manufacturer), or other service organizations. The most service is done by G.E. and their contractors and office equipment manufacturers. DCPBD offers training courses on servicing their products. Enrollment in the training classes is 60% customers and 40% G.E. service organizations or their sub-contractors.

The DCPBD Product Service department reviews Engineering's designs for implications for product service. Experience from servicing similar products is used to help improve serviceability of new products. Exhibit 10 shows the critical relations between DCPBD and customers and service organizations.

The Terminet 2000 series of printers is the first DCPDB metric product. It has been available for a year. It is too soon to tell how metric will affect the service of the product. The Product Service department at DCPBD has heard a few complaints and questions about the necessity for converting to metric. The problems with servicing the metric Terminet 2000 series of printers are not likely to be great. Waynesboro's courses for customers and G.E. service organizations on servicing these printers include sections on metric. More important, the Terminet 2000 series has been designed to simplify maintenance. As the service organization contacted put it, "the machine snaps together." Many of the parts in the printer are electrical not mechanical; this is a major change from previous printers. In 1974 a Terminet printer had 7,759 pieces. The Terminet 2000 series has about 500 pieces. This decrease in the number of parts coupled with the use of electric rather than mechanical parts is likely to soften the impact of metric on those servicing the Terminet 2000 printers.

Exhibit 10

PRODUCT SERVICE



Summary: DCPBD's Relations With Suppliers

Waynesboro deals with suppliers when it:

- buys prototype parts and equipment,
- buys unique and standard parts,
- buys production equipment,
- has its products serviced.

Purchasing unique and standard parts dominates Waynesboro's interaction with its suppliers.

Different actors play different roles in purchasing these different products. For prototypes, Engineering leads. In standard parts, Engineerint Standards is critical. In unique parts and plant equipment, Advanced Manufacturing is the lead division. For production parts and production equipment, Purchasing is a "window" between internal production and management and outside suppliers.

The key considerations at each stage of the product lifecycle are:

- price,
- availability/delivery,
- service,
- quality.

Exhibit 11 summarizes which considerations are paramount for each actor at each stage of the product lifecyle. In general, Purchasing is responsible for cost, delivery and service, while other departments focus on the quality of the products.

Conversion to the metric system had little effect on the relations between Waynesboro and its suppliers. Metric is accepted by DCPDB as well as suppliers and customers as a routine part of doing business. The few problems that arose were the exceptions, not the rule.

Waynesboro found fewer problems converting to metric than they expected. Some departments thought conversion would create a lot of problems. They found their fears were exaggerated. Conversion occurred under budget with minimal disruption to the normal operating procedures.

A major reason conversion had little effect was Waynesboro's policy of going with the market on metric -- in their terms, a common sense approach. If metric sized printed circuit boards or electrical components are not readily available, DCPBD does not pay the premiums to have them produced

Exhibit 11

CONSIDERATIONS IMPORTANT TO DCPBD IN DEALING WITH SUPPLIERS OVER THE PRODUCT LIFECYCLE

DOMINANT CONSIDERATIONS FOR DEPARTMENTS IN DIFFERENT TYPES OF PROCUREMENT

LIFECYCLE STAGE & DEPARTMENT	GENERAL ROLE	SUPPLIER/CUSTOMER RELATED DUTIES	KEY CONSIDERATIONS REGARDING SUPPLIER/ CUSTOMER
PROTOTYPE			
ENGINEERING	DESIGN	IDENTIFY SUPPLIERS PURCHASE PROTOTYPE PARTS PURCHASE MODEL BUILDING EQUIPMENT	AVAILABILITY
STANDARD PARTS			
ENGINEERING	DESIGN	PRELIMINARY DRAWING	AVAILABILITY
ENGINEERING STANDARDS	STANDARDIZE DESIGN	MONITOR SUPPLIERS SELECT SUPPLIERS DEVELOP PURCHASE PART DRAWINGS APPROVE VENDORS	QUALITY
PURCHASING	PROCURE PRODUCTS AND EQUIPMENT	IDENTIFY SUPPLIERS SEND OUT REQUESTS RECEIVE, EVALUATE BIDS PLACE ORDERS	PRICE DELIVERY SERVICE
UNIQUE PARTS			
ENGINEERING	DESIGN	PART DRAWING	
ADVANCED MANUFACTURING	PLANNING AND MAINTENANCE OF PRODUCTION	MAKE OR BUY DECISION DECIDE AMOUNT, TIMING OF REQUEST	DELIVERY COST
PURCHASING	PROCURE PRODUCTS AND EQUIPMENT	IDENTIFY SUPPLIERS SECURE AND EVALUATE BIDS SELECT SUPPLIERS PLACE FINAL ORDERS	COST DELIVERY SERVICE
QUALITY CONTROL	TEST TOOLS AND PARTS	INSPECT SAMPLES OF SUPPLIERS' PRODUCTION ACCEPT OR REJECT SAMPLES	QUALITY
PRODUCTION EQUIPMENT			
ADVANCED MANUFACTURING	PLANNING AND MAINTENANCE OF PRODUCTION	IDENTIFY NEED FOR EQUIPMENT DRAW UP SPECIFICATIONS FOR EQUIPMENT IDENTIFY VENDORS	QUALITY AVAILABILITY COST
PURCHASING	PROCURE PRODUCT AND EQUIPMENT	IDENTIFY SUPPLIERS PLACE ORDERS	COST DELIVERY SERVICE
SERVICE			
PRODUCT SERVICE	SUPPORT ORGANIZATIONS SERVICING EQUIPMENT	MONITOR DESIGN TRAIN SERVICE ORGANIZATIONS	SERVICEABILITY: • EASE • COST • EXTENT/AMOUNT
ENGINEERING	DESIGN	MONITOR SERVICE PROBLEMS DESIGN WITH SERVICEABILITY IN MIND	QUALITY

in metric dimensions. They use customary sized products. Waynesboro uses market available parts to keep the costs of production as low as possible, because DCPBD's products are in a very cost competitive market. To increase its marginal advantage in its market, Waynesboro has a cost improvement program which looks for ways to cut costs. The cost improvement program recently found that a shift from metric raw materials and bar stock to customary stock would cut costs. DCPBD was paying premium prices for the metric stock; buying customary stock and milling or grinding it to metric sizes was cheaper than buying the metric stock.

At the same time DCPDB converted to metric they instituted the "geo-metric" drawing system. This change far overshadowed the change to metric. The distinguishing feature of the "geo-metric system" is that all dimensions are related to one position on the drawing; this is also called "true positioning". Since this is not a widespread drawing practice, it created some temporary problems for both internal production and outside suppliers. These problems were more severe than any encountered as a result of metric according to DCPBD staff and suppliers.

DCPDB's move to metric is well established. The lack of problems with suppliers has increased the commitment to conversion. From the beginning, Waynesboro has taken a firm line on conversion. Unlike some firms, they do not provide dual dimensions on their drawings. Their drawings go out only with metric dimensions. There are several reasons for using only metric dimensions:

- Sometimes conversions are wrong. At first DCPBD provided dual dimensions. After a few mistakes they decided to use only the metric dimension.
- Conversions can increase the cost. For some conversions to be exact, it is necessary to go to several decimal places for the customary equivalent. This makes what may be a standard part appear to be a precision part. Similarly, the conversion of tolerances can make a standard part appear to be a precision part. If suppliers think a precision part is required, the costs increase.
- The G.E. corporate policy is to put only one type of dimension on drawings.

Conversion to metric has had very little effect on the way Waynesboro deals with suppliers. Specifically, the case study found:

- Metric fits comfortably into established patterns of dealing with suppliers;
- Waynesboro's pre-conversion concerns about metric were not borne out by their experience;
- The common sense, cost reduction approach to conversion reduced the problems with suppliers;
- Conversion had much less effect on suppliers than the change, at the same time, to geo-metric drawings;
- Unique parts encountered the most difficulties;
- Only a few suppliers of unique parts requested any assistance;
- Conversion of older plant equipment with digital readouts increased their lifetime;
- It is too early to tell what effects conversion will have on DCPBD's customers. Given the design of the product and the active training program, few problems are expected.

Waynesboro's products will become increasingly metric as new products are designed and produced and more metric parts are easily available. Customary parts will continue to be important for DCPBD in dealing with older products and those elements of the new products that cannot be converted economically. This is the effect of metric conversion on Waynesboro's relations with its suppliers. The next section looks at the effect of conversion on the suppliers.

III. EFFECTS ON SUPPLIERS

Introduction

How has Waynesboro's conversion to metric affected its suppliers? The previous section describes how conversion affected the way Waynesboro deals with its suppliers. This section looks at the other side of the conversion--the supplier side. What have suppliers done to meet Waynesboro' metric requirements? How does this compare to their normal relations with customers?

The effects on suppliers are described in two ways--how Waynesboro perceives its effects on suppliers, and the views of the suppliers on the implications of Waynesboro's conversion for them.

Waynesboro's Perception of Effects of its Conversion on Suppliers

"We had more problems internally than with our suppliers," was the response of most of the Waynesboro staff on the effect of their conversion on their suppliers. When conversion to metric was being considered in 1978, Purchasing made a telephone survey of 69 suppliers to determine their ability and willingness to go metric. The survey found 97% (67) of the suppliers could make metric products; 87% (60) were already producing parts to metric specifications. Exhibit 12 summarizes the survey findings. Exhibit 13 contains illustrative responses to the survey questions.

The results of this survey helped Waynesboro decide to convert. There would be no problem with getting the metric parts from these traditional suppliers. It has worked out that way. Conversion has not affected the nature, the number, or types of suppliers used by DCPBD. Any changes in suppliers since the conversion to metric have been the result of normal market forces. No suppliers have refused to work with DCPDB or have been dropped because of metric.

The DCPDB staff gives several reasons for the absence of adverse impacts on suppliers:

- "Suppliers are pretty hungry." They are not likely to refuse work or present DCPBD with problems in use of metric.
- DCPDB followed "a common sense approach" to conversion, converting only those parts that could be produced in metric economically. For example, they did not demand metric transformers.
- Some of their suppliers are medium to large businesses with multiple product lines and the experience and expertise in handling metric orders.

Exhibit 12

GENERAL ELECTRIC

DATA COMMUNICATION PRODUCTS DEPARTMENT
WAYNESBORO, VA. 22980

DIAL COMM 8-272-1

SUBJECT Vendor Metric Survey COPIES

May 26, 1978

J. W. Rannie
Manager-Materials

Purchasing contacted 69 suppliers to determine their present manufacturing capability with respect to the metric dimensioning system. The result of this survey found that 97% of those surveyed can manufacture their products to metric dimensions but of these 87% were actually manufacturing parts at present. The following is a detailed outline of our summary.

# of vendors contacted	69
# of vendors who can manufacture to metric dimensions	67
# of vendors now manufacturing in metric	60
# of vendors not manufacturing in metric	9
# of manufacturers who cannot manufacture in metric	1
# of manufacturers not sure as to manufacturing capability	1

Commodities covered in the above survey were:

Fasteners	Plastic Parts	Coils
Hardware	PWB	Paint
Semiconductors	Castings	Chemicals
Capacitors	Metal Gears	Resistors
Terminals	Fabricated Metal	Bearings
Springs	Transformers	Stampings
Clutches	Raw Material	Screw Machine Parts
	Copper	Machine Parts
	Steel	
	Aluminum	

R. R. Smith
Manager-Purchasing

RRS/kh

Exhibit 13

ILLUSTRATIVE RESPONSE TO SURVEY OF SUPPLIERS BY

DCPDB'S PURCHASING DEPARTMENT

May, 1981

- A Stamping Company
- A Machinery Company
- A Fabricated Metal Products Company
- A Transformer Manufacturer

Exhibit 13, cont.

VENDOR METRIC SURVEY

VENDOR A STAMPING COMPANY DATE 5-26-78

PERSON CONTACTED _____

1. DO THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS FOR OTHER CUSTOMERS?

YES ☑

NO ☐

2. IF NOT, CAN THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS?

YES ☐

NO ☐

3. IF NOT, DO THEY HAVE ANY PLANS TO DO SO?

NO ☐

YES ☐ WHEN _____

4. DO THEY FORESEE ANY PROBLEMS IN MEETING/SUPPLYING CUSTOMER REQUIREMENTS FOR METRIC DIMENSIONED PARTS?

YES ☐

NO ☑

General Electric

Exhibit 13, cont.

VENDOR METRIC SURVEY

VENDOR A MACHINE SHOP DATE 5/26/78

PERSON CONTACTED _____

1. DO THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS FOR OTHER CUSTOMERS?

YES ☒ Sky convert from metric to English

NO ☐

2. IF NOT, CAN THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS?

YES ☐

NO ☐

3. IF NOT, DO THEY HAVE ANY PLANS TO DO SO?

NO ☐

YES ☐ WHEN _____

4. DO THEY FORESEE ANY PROBLEMS IN MEETING/SUPPLYING CUSTOMER REQUIREMENTS FOR METRIC DIMENSIONED PARTS?

YES ☐

NO ☒

4/78

General Electric

Exhibit 13, cont.

VENDOR METRIC SURVEY

VENDOR A METAL FABRICATOR DATE 5/1/78

PERSON CONTACTED _____

1. DO THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS FOR OTHER CUSTOMERS?

YES ☐

NO ☒

2. IF NOT, CAN THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS?

YES ☒ will convert

NO ☐

3. IF NOT, DO THEY HAVE ANY PLANS TO DO SO?

NO ☒ only when required

YES ☐ WHEN _____

4. DO THEY FORESEE ANY PROBLEMS IN MEETING/SUPPLYING CUSTOMER REQUIREMENTS FOR METRIC DIMENSIONED PARTS?

YES ☐

NO ☒ will convert.

Existing parts should be converted to exactly what they are doing now.

General Electric

Exhibit 13, cont.

VENDOR METRIC SURVEY

VENDOR A TRANSFORMER MANUFACTURER DATE 5/5/78

PERSON CONTACTED _____

1. DO THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS FOR OTHER CUSTOMERS?

YES ☐

NO ☒

2. IF NOT, CAN THEY NOW MANUFACTURE PARTS TO METRIC DIMENSIONS?

YES ☐ maybe — could try

NO ☐

3. IF NOT, DO THEY HAVE ANY PLANS TO DO SO?

NO ☒

YES ☐ WHEN _____

4. DO THEY FORESEE ANY PROBLEMS IN MEETING/SUPPLYING CUSTOMER REQUIREMENTS FOR METRIC DIMENSIONED PARTS?

YES ☐ not sure

NO ☐

will not convert until absolutely necessary.

- Most small suppliers convert metric drawings to customary units for their production purposes.
- Very few of the metric products supplied by outside suppliers were highly measurement-sensitive--where an error introduced by conversion would significantly affect compatibility or performance.

According to DCPDB staff, a more important problem for suppliers was the introduction of the geo-metric drawing system. One staff member thought the combination of geo-metric design and metric conversion made it more difficult for smaller firms to compete on the bids for metric; they are less likely to have the experience or expertise in dealing with the geo-metric drawings. Waynesboro looks for small suppliers as a means of reducing costs; they have had little sucess, however, in increasing the small business share of DCPBD's orders.

The Suppliers' View

Suppliers confirm DCPBD's view of its effect on suppliers--no major impacts or problems:

- Conversion to metric is a routine, minor cost of doing business for small businesses; most convert metric drawings to customary units;
- DCPBD's conversion to metric has not had a major effect on its suppliers. Many produce metric parts for other companies as well as Waynesboro.
- Conversion to metric is a routine, minor cost of doing business for small manufacturers; most convert metric drawings to customary units.

These findings are based on contacts with Waynesboro's small business suppliers. The companies were drawn from a list of 149 suppliers. This list was provided by DCPBD Purchasing. It was originally a list of plant shutdowns and vacations for Waynesboro's key suppliers. There are several important features of this list:

- The list was not drawn up for the purpose of this study: it is not biased to present the most favorable impression about the effect of Waynesboro's conversion.
- It contains the suppliers considered to be most important to Waynesboro.
- It contains a diverse group of companies in terms of size, location, and products.

Of the 149 companies, the study team contacted 141; the 8 that were not contacted would not return calls or answer questions over the phone. Of the 141, 62 (44%) were large companies (those with over 500 employees). Another 4 companies contacted were distributors of products; they did not manufacture products for Waynesboro. The study team contacted 75 small businesses who manufacture products for DCPBD.

These 75 companies produce many different parts for Waynesboro and other companies. Among the products they produce are:

Tools	Wire	Fasteners
Bearings	Molded plastic parts	Castings
Discs and molds	Plastic extrusions	Rubber products
Engravings	Stampings	Fabricated metal products
Springs	Precision machine parts	Coils
Screw machine parts	Raw materials	
Gears		

The companies range in size from a nine-person machine shop to a 450 person manufacturing firm. Most of the firms have between 50 and 150 employees; the average size of the small manufacturers contacted is 120 employees. Sales ranged from $1 million to $60 million; most firms were between $3 million and $6 million in sales. Almost all the small manufacturers supplying Waynesboro are located east of the Mississippi River --

Pennsylvania, New Jersey, and Connecticut were the most common locations. Other states with a number of Waynesboro suppliers are New York, Massachusetts, Illinois, and Ohio.

Suppliers' Metric Activity

Of the 75 small companies contacted, 45 (60%) produce metric parts for DCPBD. The other 30 (40%) supply parts to DCPBD in customary units only. This is not surprising since only one of Waynesboro's product lines is metric -- the Terminet 2000 series printers. All DCPBD's older products are manufactured to customary units.

The small firms supplying metric to DCPBD supply metric and customary products to their customers; only one firm, a small specialty electronics firm, was working 100% to metric orders. Most firms devote less than 30% of their production to metric; only six of the small businesses contacted had over 31% of their production for metric orders. The average percent of production for metric orders was 27%; taking away the six firms over 31% drops the average to 16%.* The most common percentage as well as the median percentage was 25% of a small manufacturer's production for metric orders.

Suppliers' Investments in Metric Production

Without exception, the suppliers to DCPBD produce metric products without making substantial investments. None of the firms contacted reported making substantial investments. One company has spent close to $10,000 over the past 4-5 years in digital readouts and inspection equipment; however, they do not consider this investment substantial.

The overwhelming majority -- 39 of the 45 firms producing to metric -- convert DCPBD's metric drawings to customary units, usually decimal (100 millimeters = 3.94 inches), for in-house production and inspection equipment;

*These averages are based on responses from 32 of the 45 small manufacturers working in metric. Several firms were unwilling or unable to give estimates of their metric production or the percentage attributable to General Electric DCPBD. There is no reason to believe these firms are any different from those who provided such information; they are in the same types of businesses as those responding.

most inspect the product using the customary dimensions on the converted drawing. One firm estimated the time spent converting a complicated engineering drawing of the sort Waynesboro sends out at 15 minutes per drawing. Suppliers do not consider this time a major cost, just a minor annoyance with which they have learned to cope. One supplier demanded DCPBD provide dual dimensions on its drawings; DCPBD did so because this was the only known manufacturer of highly specialized plastic extrusions used by the Engineering department in developing the prototype for the Terminet 8000 printer.

The seven companies working in metric dimensions purchased machines that operate in metric dimensions. The most common example is the Traub screw machine made in Germany which operates in metric units. There is no need to convert back to customary units. These firms have also invested in digital dual readouts on their machinery.

None of the firms purchasing dual readouts or metric machines attribute these expenses solely to the conversion to metric. Other considerations such as upgrading machinery, improving productivity, increasing flexibility and versatility are also important to the decision to buy digital readouts or foreign machines that operate in metric units.

The Role of GE DCPBD in Small Business Conversion to Metric

Waynesboro's conversion has not forced or encouraged any of its suppliers to invest in converting to metric production. With one exception the suppliers contacted supply metric parts to other companies in the same or similar industries -- companies such as IBM, Honeywell, and Xerox. In only three companies does DCPBD account for more than 20% of a firm's metric production. The overall average is 13%; if the three firms over 20% are dropped, the average falls to 5%. The median percentage is also 5%. As one supplier noted, "(Waynesboro's) orders are not very large - their demand for metric is also not very large."

The three firms for whom Waynesboro accounts for over 20% of their metric production do not do very much work in metric. A small stamping firm does 100% of its metric work for Waynesboro; that metric work accounts for

around 10% of their total production. A small plastics manufacturer does 5-10% of its work in metric; almost all of that (90%) is attributable to DCPBD. Another small machine shop does 5% of its work in metric; half of that is for Waynesboro. In each case the firm has responded to metric orders by converting to customary units, not by investing in new equipment.

It is too early to tell what effect DCPBD's conversion to metric will have on customers and related service organizations. The Terminet 2000 series of printers has been on the market for one year. Discussions with one independent subcontractor to the General Electric Service Centers revealed little concern about the problems of servicing the Terminet 2000 series of printers. They said the highly modular construction of the printer will decrease service problems -- "the thing snaps together." Also the tools needed to service the printers are common tools which the service person carries as part of their "tools of the trade."

On the costs of metric products, there was disagreement among the suppliers contacted. Several said that metric did not cost more to produce even though the time was required to convert drawings. Other firms indicated that the uncertainties surrounding working in a different measurement system increases the potential for problems in production; therefore they tend to quote a slightly higher price on metric requests.

Summary

Suppliers support Waynesboro's view of the effects of its conversion -- nothing of concern. None have made substantial investments in metric production. The overwhelming majority of small businesses supplying metric parts to DCPBD convert these metric drawings to customary units. Exhibit 14 summarizes the responses of the 146 companies on the list provided by DCPBD.

Waynesboro's conversion to metric is part of a trend toward increasing metric production in the data communications field. Other companies have also begun to convert to metric; metric is becoming a common aspect

AD-A118 634 COATES (J F) INC WASHINGTON DC F/G 13/8
THE CONSEQUENCES OF METRIC PRODUCTION FOR SMALL MANUFACTURERS. --ETC(U)
FEB 82 H H HITCHCOCK, J F COATES, M M CANAVAN AA-80-SAC-X8604
UNCLASSIFIED NL

2 OF 3
AD A
118634

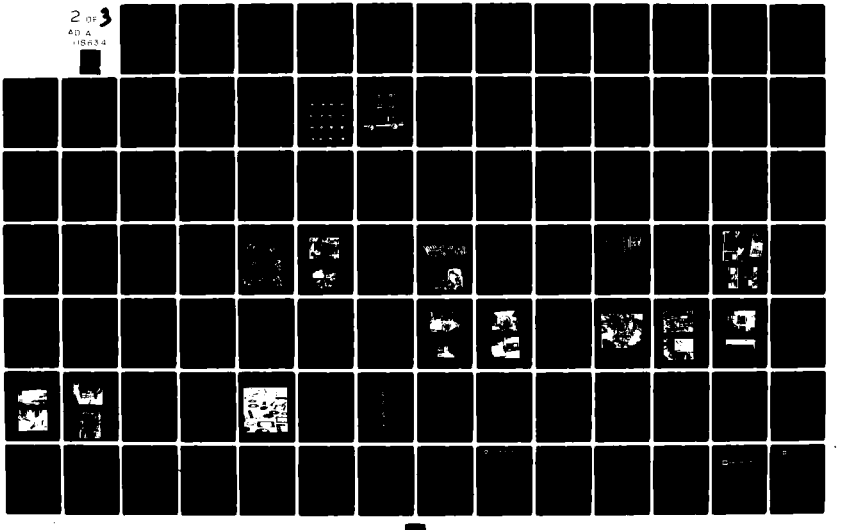
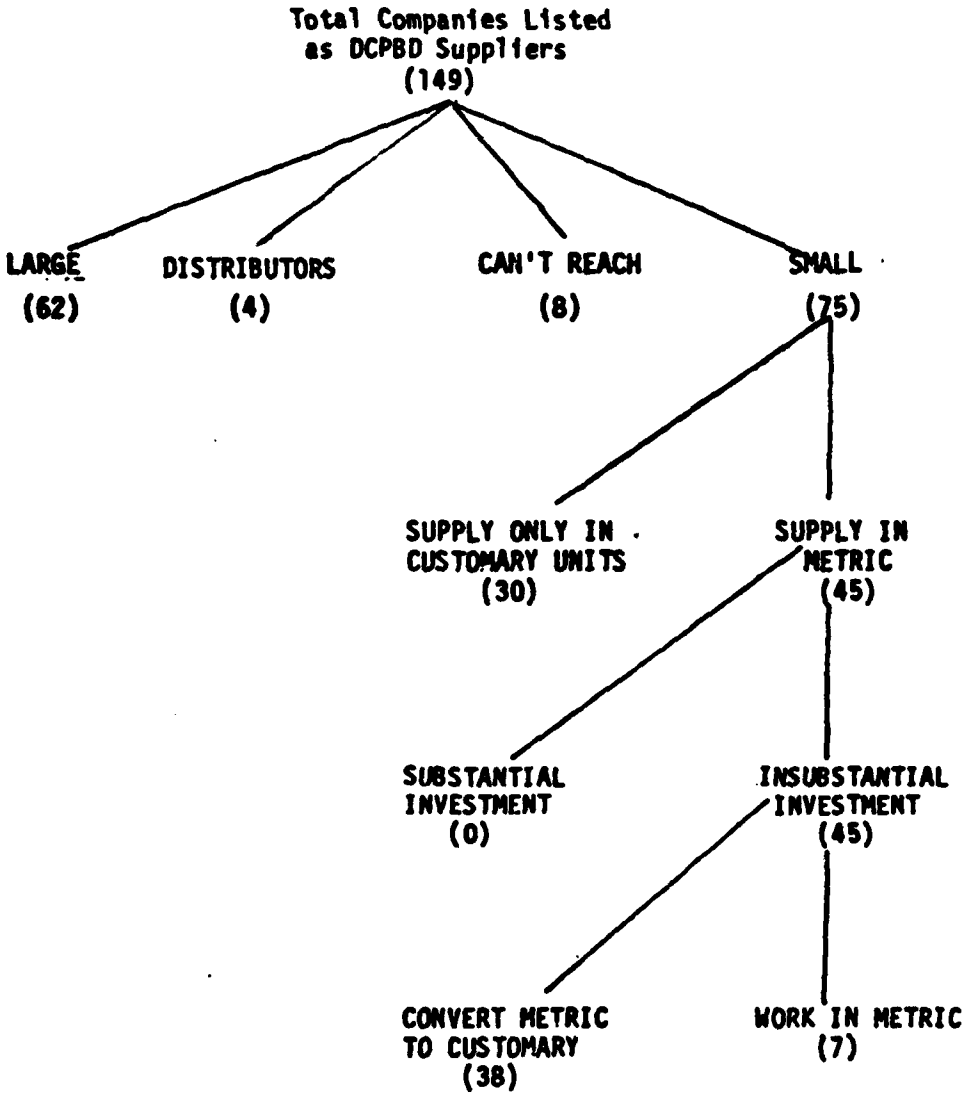


Exhibit 14

METRIC ACTIVITY IN SUPPLIERS TO DCPBD



of doing business in this area. Still, the percentage of DCPBD's small suppliers production in metric is small. Similarly, DCPBD's role in the conversion of most of its suppliers is minor. None of Waynesboro's suppliers do their business solely or predominantly with DCPBD. The size of the DCPBD's production does not warrant such a relationship with suppliers.

DCPBD's conversion to metric was more important internally than it was to their customers and suppliers. Theirs was one of a series of conversions going on in the industry. The size of their business and the timing of their conversion and their approach to conversion meant they had little appreciable impact on their suppliers. No suppliers were dropped or added as a result of metric conversion. What impact they might have had was softened by the approach of most small businesses to metric -- adapt it to the traditional methods of production using customary units. Advances in microelectronics which created the pocket calculator and the digital readout enabled small businesses to pursue this policy at little cost.

REPORT TO THE U.S. METRIC BOARD

LARGE BUSINESS-SMALL BUSINESS INTERACTION ON METRIC CONVERSION

CASE STUDY

FORD MOTOR COMPANY
Detroit, Michigan

Henry H. Hitchcock
Grant H. Prillaman
Joseph F. Coates
M. Suzanne Nettles

PREFACE

Metric measurement is increasingly common in American life -- from missiles to soda bottles, from weather to track events, from machine tools to liquor bottles. This conversion to metric measurement has raised controversy in stores, homes, schools, legislatures, factories, and offices. Why do we have to go metric? Why are we the only ones not using the metric system? When will we completely convert? Does everything have to be changed -- even football fields?

Concern and controversy have been particularly strong regarding small businesses. Will conversion hurt or help small businesses? As part of its statutory mission the U.S. Metric Board has sponsored research projects looking at the implications of metric conversion for the nation's small businesses. This study involves detailed accounts of the conversion experiences of small manufacturers. It follows a more general survey of the metric activity and attitudes in manufacturing, wholesale, retail, transportation, and construction small businesses.

In the first phase of this detailed look at small business experiences in converting to metric, the study team contacted 1161 companies to find small businesses making substantial investments in converting to metric. Although only seven substantial investors were found, an interesting portrait of the dynamics and pattern of conversion of small businesses emerged. Central to the portrait was the importance of large businesses to small business conversion to metric. Small businesses convert because their customers ask for metric products. The customers most frequently requesting metric products are large companies.

Observers have speculated, commented, or argued about the interaction of large and small businesses on metric production; little research has been done on the relationship. Case studies fill this need by looking at the costs, benefits, problems, and opportunities for small business in converting in response to large corporations' actions. They also reveal how small business supplier and customer considerations enter into large corporation decisions on metric production.

Do large companies use small companies to produce metric products? Who bears the costs of metric conversion to meet the large companies' needs? Do small businesses convert because of one or several large customers? Do small companies turn to the large companies for assistance in converting? Who benefits from metric conversion? Who is hurt by conversion? These are the types of questions addressed in these case study reports.

This report covers the metric conversion of the Ford Motor Company, specifically two lines: light trucks and the Ford Escort/Mercury Lynx.

Ford Motor Company and its suppliers actively cooperated in the case study. At Ford Motor Company, Randy Rieth, corporate metric coordinator, organized, supervised, and guided the study team in its visits to Ford. Mr. Henry Pyszynski of the Experimental Parts Purchasing set up a roundtable discussion with prototype suppliers. Other Ford personnel who generously gave time to the product include: from Light Truck Engineering: Beth Ardisana, group leader; Rob Stevens, design engineer; Steve Carl, design engineer; Larry Kepner, design engineer; Ray Schneider, design engineer. From Body and Assembly Purchasing: John Hurst, purchasing agent; Joe Fisher, buyer; Don Sitarski, buyer; Carlo Corte, senior buyer, Experimental Parts, Purchasing, Purchasing and Supply Staff; Ron Theisen, buyer. From Automotive Assembly Division: Stanley Buczkowski, Supplier Quality Assurance. From Metal Stamping Division: John Bernard, Manager, Production Equipment Design, Engineering Department. From Glass Division, Fabrication Process Engineering: Jim Whitfield, Supervisor; Roy Ferguson, Engineer.

Many Ford suppliers spent time with the study team discussing their experiences with metric. Without their cooperation this report would not have been written. The team especially benefited from the assistance of: Gary White, Plant Manager and Carl Robinson, Manager, Quality Control--Anderson-Bolling Co.; Jack Schneider, Vice President--Dudek & Bock Co.; Almer Duvall--Marben Corporation; Jim Schmiedeknecht, General Manager, Manufacturing--MacLean-Fogg Company; Allen Templin, Manager of Engineering--Midwest Fastener Corporation; Shield Barton--Nassau Machine Products Company; Don Marshall, Sales Manager--Nyloncraft, Inc.; Charles Russell, President--Progressive Stamping Company, Inc.; and Rick Duquette--Sterling Plastics, Inc.

At the U.S. Metric Board, Gene Visco, Ed McEvoy, and Stan Parent were attentive, interested, and involved patrons. At J. F. Coates Inc., Marcy Canavan talked with Ford dealers and service organizations. Bernice Mann, Barbara Bullard, and Rhoda Baum were responsible for the production of the report.

This report was prepared for the U.S. Metric Board under Contract Number AA-80-SAC-X8604. Any opinions, findings, conclusions, or recommendations expressed in the report are those of the authors and do not necessarily represent the views of the U.S. Metric Board or the Ford Motor Company.

TABLE OF CONTENTS

EXHIBITS

EXHIBITS (continued)

SUMMARY

General Findings

Ford's new cars and trucks are designed and produced in metric dimensions. Small businesses supplying parts to Ford and dealers servicing those cars and trucks easily accommodated Ford's demands for metric. The reasons for this ready acceptance of metric include:

- Ford's suppliers work for the other large automakers as well. Since Ford was not the first to convert, it has primarily added to its suppliers' metric business; in only a few cases have suppliers developed a metric capability in response to Ford's conversion.
- Metric cost small manufacturers little because in many cases Ford paid for the tooling and gauging -- the most measurement sensitive aspects of production; this is common practice in the industry whether the part is metric or customary. Most of the small businesses which made what they consider significant investments converting to metric (less than 10% of all small metric suppliers), decided to buy their own tooling so they could market metric products to other companies.
- Suppliers would not let metric stand in the way of a major account like Ford. Metric fit comfortably into the established ways Ford deals with its suppliers.
- Ford does not care whether its metric parts are produced in customary or metric dimensions as long as the quality is acceptable. Most suppliers choose to work in customary. Quality problems have not increased as a result of metric conversion.

The Case Study

The general finding above and the detailed findings below come from a case study of Ford Motor Company's conversion to metric -- specifically, the conversion of light trucks (under one ton) and the Ford Escort/Mercury Lynx to metric dimensions. The case study looks into how small businesses

respond to large corporations' metric needs. Large customer demands often drive small business conversion to metric.

Previous research led to hypotheses about the interaction among large and small businesses on metric. The study team investigated the hypotheses through interviews with appropriate departments in the Ford Motor Company, phone contacts with 255 small business suppliers, interviews with 9 small suppliers making substantial investments in converting to metric, and discussions with 5 Ford dealers on the consequences of Ford's metric conversion.

Detailed Findings

The detailed findings emerging from the contacts and interviews are grouped into six general headings:

The Ford Approach

- Ford did not anticipate any problems with its suppliers as a result of metric conversion. None have been encountered.
- Some standard parts -- such as U joints and ball joints -- would be too costly to change to metric. Everyone uses the same standard sizes. Thus, the new Ford cars and trucks are not completely metric.
- Metric has not affected the way Ford departments deal with their suppliers. It fits comfortably into established patterns.

The Metric Suppliers

- Most suppliers to Ford's light truck and Escort/Lynx plants are supplying metric parts. Of the 255 small suppliers contacted, 86% are providing metric products. Only 17 provide customary products exclusively.
- Half of these small metric manufacturers have fewer than 100 employees; the small metric manufacturer supplying Ford averages 140 employees.
- For the small suppliers of metric products, the average of production devoted to metric is 51%; half devote 50% or less of their production to metric.

- Most suppliers respond to Ford's metric demands by converting to customary units (109). A sizable number of companies (92) produce in metric or in metric and customary; produce in customary but inspect in metric (35).

Ford's Role

- Ford accounts for an average of 43% of its small suppliers' metric business. For half the companies, Ford accounts for 35% or less.
- Ford's conversion followed the conversion of other large automakers such as General Motors. Most of Ford's suppliers also work for the other auto companies.

Investment in Conversion

- Suppliers have spent little converting to metric; 86% spent less than $10,000.
- For many small manufacturers, Ford pays the tooling costs. Since tooling is often the most measurement sensitive aspect of the production, this reduces the cost of conversion for the small supplier.
- Companies servicing Ford cars and trucks -- Ford dealerships -- have not made substantial investments because of metric products.

Substantial Investors

- Less than 10% of the small metric manufacturers supplying Ford (20 companies) have spent over $10,000 converting to metric and consider their investment significant for their company.
- The substantial investors were most likely to produce metric items using metric and customary measurements or just metric measurements. Only two produce metric products using customary measurements.
- Some suppliers making substantial investments chose to for business reasons; they preferred to buy their own tooling so it could be used for other customers rather than allow Ford to pay for and thereby own the tooling.

Effects of Conversion

- Suppliers have not dropped from Ford's supplier list or been added to the list because of metric. Existing suppliers have adapted readily to the demand for metric.
- The quality of suppliers' products has not been affected by the conversion to metric.
- A few suppliers complained of a lack of standardization across the different automakers -- especially regarding fasteners. This uncertainty increases the number of tools needed to respond quickly to the automakers' needs. This, in turn, increases the investment in a metric capability. (Ford has well-developed metric fastener standards for all vehicle fastener applications. The Ford Standard Parts Manual is distributed to suppliers on a subscription basis.)
- Small businesses supplying metric parts to Ford do not think they have benefited from working in metric; most converted to keep current customers' business. Only a few have made efforts to expand markets based on metric capabilities.

I. CASE INTRODUCTION

Introduction

Do large companies drive the metric conversion of small businesses? To investigate this question, the U.S. Metric Board sponsored case studies on the interaction of large businesses and small businesses on metric production. This case study concerns one of America's largest, most visible companies -- Ford Motor Company. The case study looks at how Ford's conversion to metric has (a) affected its relationship with its suppliers, and (b) affected the suppliers themselves. This section gives some background on Ford Motor Company's conversion to metric, how the case study was done, and what the rest of the report contains.

Why Ford?

Ford Motor Company is one of America's industrial giants. Every year it produces millions of cars, trucks, and other vehicles here and abroad. It employs hundreds of thousands of people and uses the services and products of thousands of businesses. The automobile industry is an industry which affects one out of every six businesses in the United States.

For ten years, the automotive industry has been a leader in converting to metric. When Ford decided to convert in 1978, it followed the general industry trend. Since Ford's conversion is relatively recent, it offers the best chance of getting suppliers to make estimates of the costs, benefits, problems, and opportunities associated with Ford's conversion.

A hypothesis guiding the case studies is that conversion to metric is most likely to severely strain the capabilities of small business suppliers, when a big customer company converts to metric. The large orders, the large number and diverse group of suppliers, the recent conversion, and the willingness of Ford Motor Company to participate in the case study made this a valuable case study.

The Focus of the Case Study within Ford

Ford has hundreds of divisions and plants around the world. Among these, the study team looked for those areas of Ford that were farthest along in converting to metric. According to the corporate metric coordinator and other Ford personnel, the new light trucks and the Ford Escort/Mercury Lynx were the most extensively metric vehicles. A brief review of the history of metric at Ford indicates relative prominence of the light truck and Escort/Lynx in Ford's experience with metric.*

Ford's entry into metric came in 1963 with Ford's German car, Taunus, which was designed in the U.S. and dual dimensioned for potential production in the U.S. and abroad. In the late 1960's, Ford's U.S. operations designed a metric car -- the Cardinal; it never reached production. At the time, Ford's European subsidiaries had worked in metric for many years. Ford of Europe, Ford's largest overseas subsidiary, officially adopted S.I. metric in 1970. The first Ford metric product to be marketed in the U.S. was the Capri, designed in Germany and built in Germany and Britain. Previous imports -- the Cortina, the Anglia, and others -- had been built to customary specifications. The introduction of the Capri did not create any major service problems for the Ford dealers.

The 1971 Pinto was the first Ford produced in the U.S. with metric content. The engine, transmission, rack and pinion steering, and some of the fasteners were metric. The decision to produce the Pinto engine in metric followed a desire to move production of the engine outside the U.S. Most of the conversion occurred in the Lima, Ohio plant where the engine was being produced. Training, design, tooling, gauging, and manufacturing techniques within the plant had to be changed to produce the metric engine and drivetrain. When Ford encountered some problems in getting metric drills and metric taps, the engine was redesigned to make use of easily

* Much of this history is based on S.E. Mallen, "Metrication, Ford's Metric Engine Case History and the Optimum Metric Fastener System" (June, 1974).

available drills and taps. In general, Ford considered its experience with the Pinto engine successful.

Ford did not convert totally to metric with the production of the metric Pinto engine. In 1974, an in-house corporate letter said Ford would go metric under a "cost avoidance" policy, indicating some measure of reserve for conversion among Ford management. By 1979, the attitude had changed; another corporate directive letter said the company would go metric "at minimum incremental cost." This directive recognized and promoted ongoing efforts to design cars for the domestic market in metric.

Ford converts to metric only on new programs. A program is a new type of car or truck, such as the Mustang or the Escort. Ford does not convert existing product lines to metric; for example, the most recent model year of the Ford Econoline van had some modifications, but they were done in customary units because the vehicle was designed (in the 1970's) in customary units.

Metric has gradually worked its way into the design of Ford cars and trucks. The last completely customary program was the 1978 Ford Fairmont/Mercury Zephyr introduced in fall 1977. The Mercury Marquis/Ford LTD* introduced in fall 1978 was the first vehicle designed substantially in metric. The F-Series light truck model line and four wheel drive Bronco were substantially metric when introduced in fall 1979. The entire domestic car and truck line was an average of 20% metric by model year 1980 (fall 1979). The Ford Escort/Mercury Lynx, introduced in the 1981 model year (fall 1980), has the most metric parts of any Ford domestic car or truck; 93% of its parts are metric. The 1983 Ford Ranger -- a new, downsized light truck scheduled for introduction in the spring of 1982 -- is also predominantly metric.

Light trucks and the Escort/Lynx were the first vehicles produced by Ford that were almost completely metric. Their production involves a large number of suppliers. And conversion was recent enough to enable suppliers to recall the effect of their conversion but old enough to allow some experience with the product service. For these reasons the team chose them as the focus of the case study.

---

*Similar new products are often marketed by both Ford Division and Lincoln-Mercury Division of the Ford Motor Company.

The team selected light trucks as the primary focus for the case study for several reasons -- market leader, high volume, external supply, and similarity to car production patterns.

Engineering, production, and purchasing relationships with suppliers are similar for light truck and automotive programs. There are differences in organization and management style between the two. According to the metric coordinator, these differences had little bearing on the way metric entered into Ford's relation with suppliers.

Light trucks are all those trucks with payloads of a ton (i.e., 2000 lbs. U.S.) or less. Trucks with payloads of more than a ton are medium or heavy trucks. Ford is the leader in the domestic truck market. In 1978, 4.3 million trucks -- imported and domestic -- were sold in the United States. Of those, Ford sold 1.4 million, including 956,600 pickups. That makes the Ford pickup the best selling vehicle -- car or truck -- in the United States. Ford traditionally captures 1/3 of the light truck market. Ford's primary competitor is General Motors. Imports, especially Japanese, are increasingly competitive with the smaller trucks in the Ford light truck line. Light trucks include:

- small pickup -- Courier (imported from Toyo Kogyo), Ranger (1983)
- half-ton pickups -- F-100, F-150
- Three-quarter-ton pickup trucks -- F-250
- one-ton pickup -- F-350
- four wheel drive -- Bronco
- vans -- Econoline

See Exhibit 1 for exterior views of these vehicles.

Light trucks are built mostly from parts purchased from outside suppliers. Cars have a higher percentage of parts made by other Ford divisions.

The study team also looked at the Escort/Lynx experience. (See Exhibit 2 for exterior views of the Escort/Lynx.) When talking with Ford personnel about light trucks, the team probed to see if there was any difference for the Escort/Lynx. Similarly, in contacting suppliers, the team contacted all the suppliers for the Michigan Truck Plant, which produces F-Series and Bronco light trucks, and the Wayne Assembly Plant, which produces Lynx/Escort. Many suppliers work for both plants.

Exhibit 1

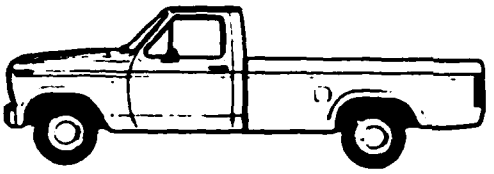
Light Trucks

"F" SERIES 100 150 250 350

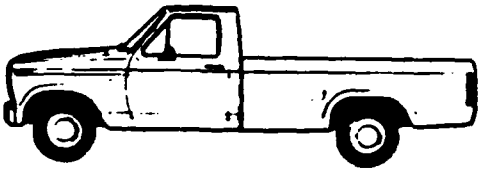
- STANDARD
- CUSTOM

- CUSTOM
- RANGER
- XLT
- LARIAT

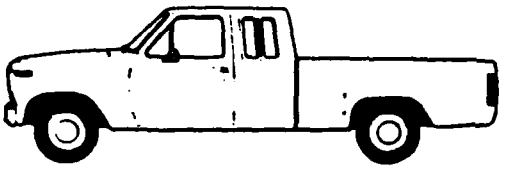
SPECIAL VEHICLES
- EXPLORER
- OLYMPIC (BRONCO)



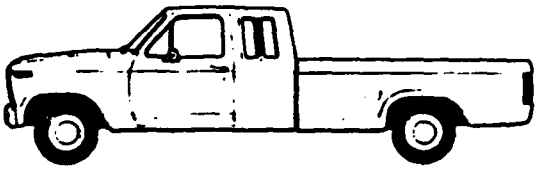
6' BOX BASE CAB
116.8 WB



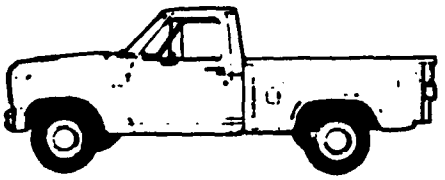
8' BOX BASE CAB
133.0 WB



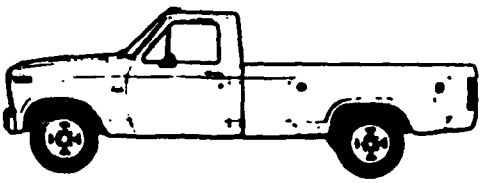
6' BOX SUPER CAB
138.8 WB



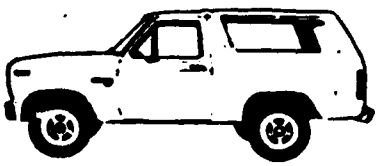
8' BOX SUPER CAB
155.8 WB



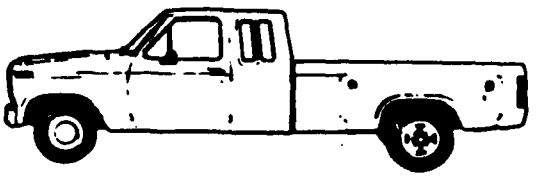
6' BOX FLARESIDE
116.8 WB



8' BOX DUAL REAR WHEELS
133.0 WB



BRONCO 104.7 WB



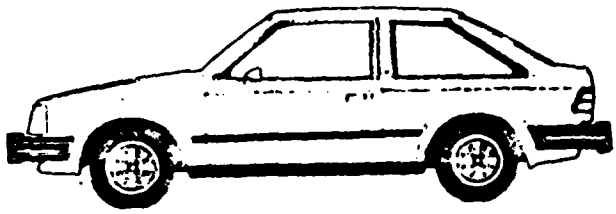
8' BOX SUPER CAB
DUAL REAR WHEELS 155.8 WB

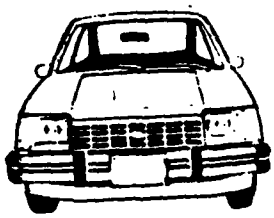
Exhibit 2

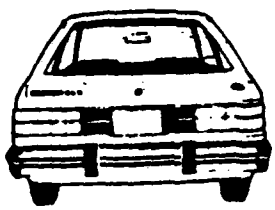
Ford

ESCORT/LYNX

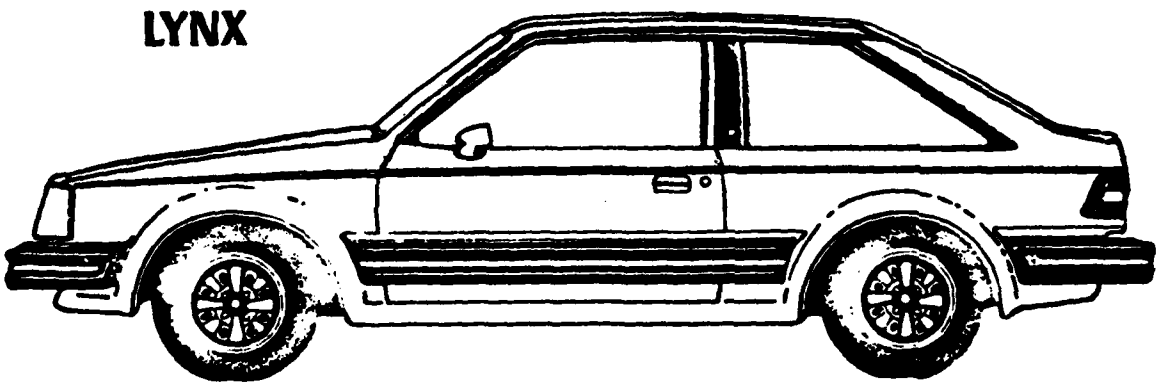
1982 ESCORT







LYNX



Lynx Tu-Tone Paint Option Shown on a GS 3-Door Hatchback

Ford converted to metric to "facilitate global production, interchangeability, and service." This was symbolized by the move to the "world car" -- a car composed of parts manufactured around the globe. Metric conversion flowed out of Ford's desire to increase its production flexibility. In part, the desire for flexibility resulted from other nations' local content laws demanding, in effect, that a company producing in that nation had to export a certain percentage of its production. To handle that requirement, Ford exports parts made to metric dimensions in that country to its domestic operations in the United States.

Conversion is underway at Ford. The light trucks and Escort/Lynx experience revealed few significant problems. Metric is not an important concern for Ford -- from the limited time allocated to metric coordination to the lack of concern in the engineers and buyers who constantly work in metric. Metric is integral and routine to the way Ford does its business, inside as well as with suppliers and customers. This case study reports how Ford's change from a customary to a metric company affected the many small businesses working with Ford.

How the Case Study was Done

The team contacted Ford Engineering and Research Staff to see if Ford would be willing to participate in a case study. With their concurrence, the team and Ford's metric coordinator decided to focus on light trucks and the Escort/Lynx.

First, the team talked to the departments within Ford working on light trucks and Escort/Lynx. These included:

- Light Truck Engineering
- Body and Assembly Purchasing (includes light truck purchasing)
  - Experimental Parts Purchasing
- Automotive Assembly Division (includes light truck assembly)
  - Supply Quality Assurance
  - Metal Stamping Division
- Glass Division -- a basic manufacturing division

Engineering, Purchasing, and Supply Quality Assurance have the most contact with suppliers. Discussions with Metal Stamping Division and Glass Division covered the use of outside suppliers for production equipment. Automotive Assembly Division assembles the parts produced by other Ford divisions and outside suppliers into cars, trucks, and other vehicles.

In the interviews, the team discussed the conversion of:

- prototypes
- production parts
- production equipment
- parts and service

The key considerations were:

- How has Ford's conversion affected small suppliers and customers?
- How have considerations of small suppliers and customers affected the extent, timing, cost, and overall experience of conversion within Ford Motor Company?

Body and Assembly Purchasing gave the team the complete supplier lists for the two local plants working on light trucks and Escort/Lynx -- Michigan Truck and Wayne Assembly Plant, respectively. Seven plants around the country make light trucks; two make Escort/Lynx. The two lists had 653 company names. Using Thomas Register and Standard and Poor's Million Dollar Directory, the team identified 278 large (over 500 employees) or foreign companies. The team was unable to contact 28 of the companies on the lists. The team contacted a total of 347 companies.

In these contacts, the team asked if the company was a small, independent business -- a business with less than 500 employees that is not a subsidiary to or an affiliate of a larger company. Of the 347 companies contacted, 255 were small independent manufacturers. The team asked these small manufacturers if they produced metric products for Ford or any other companies; 86% of the 255 produced metric products. Of those 86%, the team inquired about the costs, benefits, problems, and opportunities. The team was looking for small manufacturers that had made substantial investments in converting to metric.

The team used two criteria to identify small manufacturers making substantial investments in metric production. Based on previous research, the amount of $10,000 was used as a dividing line between substantial and insubstantial investments in metric. More important, the team asked companies if they considered their investment in metric conversion significant to their company. Using these two criteria, the team located 20 companies that spent over $10,000 on metric conversion and considered the investment as a significant one.

The study team visited nine Ford suppliers. The visits resulted in more detailed descriptions of the reasons, methods, costs, problems, benefits, and opportunities associated with converting to metric. Two of the firms visited spent less than $10,000 converting to metric. Another two spent over $10,000 but did not consider the investment significant. The other five companies visited invested substantial amounts in metric and considered the investment significant. Discussions with the other 15 companies who considered their investment significant indicated their experiences were quite similar to those of the five companies visited. Therefore, the team did not make additional visits.

Ford Parts and Service Division suggested contacting local Ford dealers for information on the consequences of metric conversion for people servicing Ford products. The team contacted five Ford dealers in the Washington, D.C. metropolitan area concerning the effects of Ford's metric conversion.

A draft report was prepared on the basis of the interviews with Ford and its suppliers and the phone contacts. Sections of the draft report were circulated to the companies interviewed for their review. The report was revised on the basis of those reviews and submitted to the U.S. Metric Board. Exhibit 3 shows the steps the case study took.

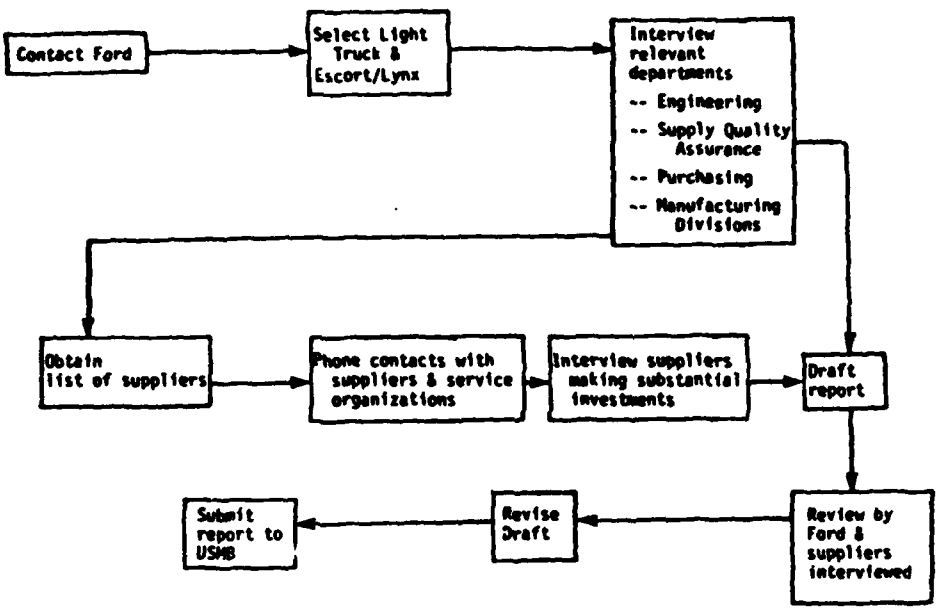
What Follows

The case study report's two sections discuss:

- The implications of supplier consideration for the Ford's conversion, and
- The effect of Ford's conversion on its suppliers.

Exhibit 3

FORD CASE STUDY FLOW



The next section describes how metric conversion fits into the established pattern of relations between Ford and its suppliers. The final section discusses Ford's effects on its suppliers including Ford's perception of the effects and the suppliers' own reports.

II. METRIC CONVERSION AND FORD'S RELATIONS WITH SUPPLIERS AND CUSTOMERS: THE VIEW FROM FORD

Introduction

This case study of small business-large business interaction follows two paths -- the effects of conversion on small business suppliers and customers and the effects of metric conversion on the way the large company relates to its suppliers. Relations with suppliers refer to:

- Involvement of suppliers in design decisions.
- Effect on design of customer and service organization considerations.
- Effect on design and production of supplier capabilities.
- Interaction and the relative importance of different divisions dealing with small suppliers.
- Primary considerations for each department in its relations with suppliers.

Ford made no changes in its relations with suppliers as a result of metric conversion. Metric fits comfortably into the established ways Ford designs and produces cars, trucks, and other vehicles. The rest of this chapter elaborates this general finding.

Suppliers and the Product Lifecycle

The first car that rolls off the assembly line is the product of over 5 years of planning, building, revising, testing, buying, and manufacture. This complex sequence involves many different Ford divisions, thousands of suppliers, and millions of different parts.

Suppliers are involved throughout the product lifecycle. They provide advice on design, supply prototype parts, supply parts for production, provide machines and tools (production equipment) to the divisions of Ford working in metric, and service and repair Ford products. Ford uses over 2500 suppliers; most work on parts for production. Many are also involved in supplying parts for repair and replacement. Customers are mostly involved in servicing products and, to a lesser degree, in advising on product design. Before turning to the specifics of suppliers' relations with Ford, the next section describes the general Ford approach to metric conversion.

The Ford Approach to Metric Conversion

Ford chose to convert to metric as much as economically feasible. Within several years they went from the totally customary Fairmont/Zephyr to the 93% metric Escort/Lynx. Even on the Escort/Lynx a number of parts could not be converted economically. Standard items (such as ball joints or U-joints) used by many different companies in the U.S. and around the world are designed in customary units. To demand metric ball joints or U-joints for Ford's production would have cost too much. Ford continues to use the standard items.

When Ford converted to metric, they briefly listed customary and metric dimensions on their drawings. Within months, they stopped providing the customary equivalents; since then, all Ford drawings have only metric dimensions unless they refer to a customary part such as a ball joint. Having only metric dimensions reduces the possibility of error by Ford. If an error in converting is made, Ford would rather it be a result of suppliers' errors than their own.

Ford did not consider its conversion to metric a major issue, either internally or externally. Ford notified many of its suppliers that it was converting to metric. For others, prints began showing up in metric. There were a number of videotapes on metric available to the Ford departments. Overall, Ford did not treat conversion as a significant event. Suppliers and employees were expected to adapt to the change without difficulty.

Concept Development and Advanced Engineering

Suppliers assist engineers and designers working in metric the same as they did when cars and trucks were designed in customary units. Suppliers providing assistance have not changed as a result of the metric conversion. Initially, people had difficulty remembering which system of measurement they were using -- this was as much, if not more, of a problem internally than with outside suppliers. Exclusive sourcing arrangements did not increase as a result of metric conversion; they remain rare and involve primarily electronic equipment.

Production Engineering - Prototypes

A key part of the job of engineering is designing, building and testing prototypes. Metric conversion has not affected the purchasing of prototype parts. At first, there were a few minor problems with parts exceeding tolerances; these disappeared soon. Experimental Parts Purchasing uses the same suppliers now as it did when vehicles were designed in customary units. The only differences are those resulting from normal market forces. Experimental Parts Purchasing did not expect any problems with its suppliers dealing with metric conversion. Most prototype suppliers were already working for foreign automakers. Also, prototype suppliers are highly skilled craftsmen used to working on customized or special parts. Metric is treated like any other special characteristic required by the customer.

Production Parts

Metric conversion of Ford's products has not changed the way Ford deals with its suppliers of production parts. The cost of parts has not changed as a result of metric; at least, the effect of metric could not be separated from the overall increases due to inflation, rising wages, and increasing interest rates. Production Purchasing has not changed its suppliers as a result of metric. They also have not heard any complaints regarding metric from their suppliers. As Purchasing explained, suppliers are not apt to let metric stand in the way of a major account such as Ford.

Ford people give two reasons for the lack of effect: (1) suppliers usually work for the whole industry and the entire industry has been converting over the last several years, and (2) suppliers to the auto companies make high quality products; metric is not going to be difficult for them.

Production Equipment

Make or buy decisions are critical steps in the product lifecycle. Early in the product lifecycle, engineers decide along with the cost experts whether to produce a product using in-house Ford capabilities or outside suppliers. The decision to make or buy a product depends on costs, labor rates, capacity, delivery times, service, quality, and other factors.

Ford's Basic Manufacturing Divisions use suppliers for equipment, tools, dies, fixtures, and gauging. Like other Ford suppliers, they usually convert metric orders to customary units in order to produce it. Most of the measurement sensitive aspects of production -- the tooling -- are produced by outside suppliers.

Automotive Assembly Division does not use much measurement-sensitive equipment aside from hand tools and the like. It has not had to make major investments because of Ford's conversion.

Metric conversion has not affected the procurement of production machinery by Ford's Basic Manufacturing Divisions or its Automotive Assembly Division. The most measurement sensitive aspects are supplied by outside tool and die suppliers. Many divisions continue to work in customary units, converting only the tooling that makes the part into metric. Gradually, the divisions are increasing their metric capability. As new machines are purchased, they have dual capabilities. In the Glass Division, more machinery is metric because high quality glass making machinery is made in Europe. As the Glass Division upgrades its production capacity, a byproduct will be the development of a metric capability.

Product Service

After production, suppliers are called upon to supply spare parts for Ford products. These spare parts will increasingly be in metric dimensions. The suppliers of spare parts are usually those that made the production parts. Since the Ford metric products have been on the road less than two years, the effect of conversion on spare parts remains uncertain.

Ford Parts and Service division advised the team to ask the dealers about the consequences of metric conversion for servicing Ford products. The Parts and Services division issued two reports in its monthly magazine to dealers, Shoptalk, about metric.

Production Engineering is involved in parts and service work. When service issues arise, the engineers that developed the part handle them. The engineers have not seen an increase in service issues as a result of metric.

Summary

The lifecycle for producing a car or truck has easily accommodated conversion to metric. Ford relates to its suppliers the same ways it did when working in customary units. The initial confusion has passed. Metric is now integral to the way Ford does its business. Suppliers and customers have, in Ford's view, easily accommodated to the change. A major reason for the lack of effect is the traditional industry practice of the customer paying the tooling costs, the initial gauging costs, and the fixture costs. Designed to promote manufacturing flexibility, this custom has made metric a minor issue for Ford and its suppliers.

III. EFFECTS OF FORD'S CONVERSION ON SUPPLIERS AND CUSTOMERS

Introduction

How has Ford's conversion to metric affected its suppliers and customers? The previous section described the implications of metric conversion for the way Ford deals with its suppliers. This section follows the different phases of the product lifecycle to describe effects on prototype suppliers, production parts suppliers, and Ford dealers. Before turning to the impacts on these suppliers and customers, the section describes Ford's perception of its impacts on suppliers and customers.

Ford's View of the Effects of its Conversion on Suppliers and Customers

Ford did not anticipate its conversion would present any problems for its suppliers. They did not conduct a survey of suppliers' capabilities to produce metric. They assumed their suppliers would be able to handle their metric orders. Ford personnel and some suppliers say suppliers were notified of Ford's conversion; others say prints began showing up with metric dimensions.

Ford personnel believe suppliers have responded to Ford's metric conversion without any problems or significant costs. They attribute the absence of problems to several factors:

- Few suppliers work exclusively for Ford; most work for the three major automakers. The industry has gradually been moving into metric over the last decade. Ford was not the first to convert, so it benefited from the conversion of suppliers to meet the other automakers' needs.
- Suppliers are not likely to let problems with metric stand in the way of a major account such as Ford. The economic climate of the past decade -- especially the past two years -- has made this even more true.
- Suppliers to the auto industry are, according to Ford personnel, highly skilled companies; they are unlikely to have problems with metric conversion.

- Most suppliers respond to metric orders by converting Ford drawings to customary units. The only expenses they have, according to the people at Ford,are for quality assurance equipment. For most suppliers, Ford pays the tooling costs -- the most measurement-sensitive aspect of production.

The industry trend toward metric, the economic climate, the skill level of the suppliers, and conversion to customary dampened any impact Ford's conversion might have had on its suppliers.

Ford personnel do not think there have been any problems regarding metric for dealers and companies servicing Ford products. The Ford Parts and Service Division has not heard complaints from dealers on metric. Dealers appear to be treating metric like any other change in the product line.

Suppliers' Views on the Effects of Ford's Conversion to Metric

Ford suppliers and customers confirm Ford's view of the impact of its conversion: no major problems and little cost. Ford's conversion has not had a significant positive or negative effect on suppliers. Suppliers cite the same reasons as Ford personnel for the lack of effect from Ford's conversion:

- Ford is only one of the major automakers converting to metric; they were not the first to convert.
- Most of Ford's metric parts can be produced using customary dimensions; most suppliers choose to do so.
- Ford pays much of the cost of working in metric -- tooling, fixtures, and gauging.
- The primary cost for the small manufacturer is general quality control equipment.

These observations are based on contacts with 15 prototype suppliers, 255 small manufacturers of production parts, and 5 Ford dealerships in metropolitan Washington, D.C. The Body and Assembly Purchasing Division of Ford gave the team names of prototype suppliers and a complete listing of the suppliers for the two plants near Detroit producing the F-Series of light trucks and the Lynx/Escort -- the Michigan Truck and Wayne assembly plants. Ford Parts and Service Division suggested contacting local dealers for an understanding of the implications of conversion for the dealers of Ford products.

The following sections describe the views of the prototype suppliers, production parts suppliers, and Ford dealers on the effects of Ford's conversion to metric.

Prototype Suppliers

With the assistance of Experimental Parts Purchasing, the study team contacted 15 small manufacturers making prototypes for Ford. These companies work only on prototypes for Ford. Prototype suppliers vary in size from small machine shops to large small businesses -- from 30 employees to 300 employees. Most had less than 100 employees. Prototype suppliers work predominantly for the automotive industry; they usually work for two or more of the auto companies. None of the companies we contacted worked solely for Ford.

Metric accounts for 10% to 90% of the total production of the small manufacturers contacted. The average prototype firm was producing half its products in metric. Ford accounts for between one-third and one-half of the prototype suppliers' metric business.

Most prototype suppliers respond to Ford's metric orders by converting the metric drawings to customary units for production. Two of the newer companies contacted work in metric; when they set up business several years ago, they realized there would be an increasing amount of metric business. They purchased equipment that had dual capabilities. They use the metric capability when the drawing is in metric.

For those companies not working in metric, the time spent converting is a minor cost -- one supplier estimated two to four hours over the course of a four- to six-week job. Some of the prototype suppliers reported minor expenses for quality control equipment.

Metric conversion has not been a problem for small prototype suppliers. It also has not been much of a benefit. Business has not expanded as a result of metric conversion. At best, conversion has allowed the small prototype suppliers to maintain their business with the automakers. At worst, metric has been a nuisance for the small prototype suppliers. It has not presented any major problems for these suppliers; they are used to working on specialty, customized items. Metric is just another special feature to the prototype suppliers.

Production Parts Suppliers

Most of Ford's suppliers produce parts for the full scale production of Ford's cars and trucks. The demand for parts can range from several hundred for spare parts to millions for parts used on numerous vehicles. Suppliers include local machine shops and multinational corporations. Production suppliers are the most likely to make substantial investments in metric production because they deal with the largest volume of demand for metric. Therefore, the team focused most effort on contacting production parts suppliers.

The Suppliers

Using the two lists of suppliers to Michigan Truck and Wayne Assembly plants, the study team contacted 255 small production parts manufacturers.

The 255 small manufacturers -- independent businesses with fewer than 500 employees -- supplying Wayne and Michigan Truck assembly plants make many different products. The primary materials they use are metal, rubber, and plastic. Some parts are quite large such as body stampings; others are very small such as cotter pins. Exhibit 4 lists some of the products made by the companies contacted.

At least half of the companies are located in Michigan -- many around Detroit. Other areas of concentration include Chicago (including nearby areas of Wisconsin and Indiana), Akron, Toledo, Cleveland, Philadelphia, and northern New Jersey.

The companies range from small machine shops to large, multi-division small businesses with almost 500 employees. Several businesses contacted had once had more than 500 employees. Because of the decline in the fortunes of the auto industry, they had cut back to fewer than 500 employees. If they converted while they had more than 500 employees, the team counted them as large companies. If they converted after they had fewer than 500 employees, they were counted as a small metric manufacturer. Exhibit 5 shows the distribution of the sizes of the small metric manufacturers contacted.* The average business contacted had 140 employees. Half of the companies contacted had 100 or fewer employees. Thus, many of the businesses contacted were relatively small manufacturing firms.

---

*The team contacted 238 small metric manufacturers. Some of these companies did not answer some of the team's questions. As a result, the number of companies reported on the exhibits vary.

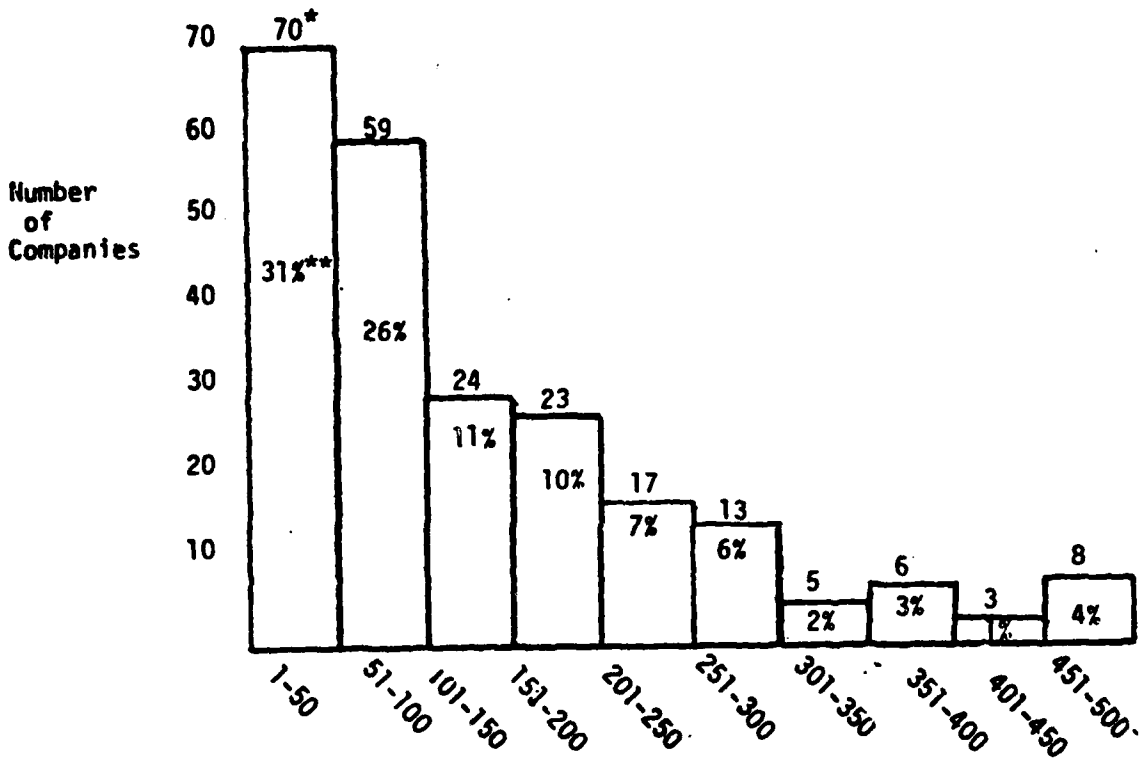
Exhibit 4

PRODUCTS PRODUCED FOR FORD BY SMALL METRIC MANUFACTURERS

Stampings	Brackets	Dipsticks
Fasteners	Felt	Lenses for Lights
Plastic Molds	Foam Pieces	Light Assemblies
Wire	Screw Machine Parts	Visors
Wire Mesh	Dials	Carpeting
Rubber Molded Products	Ducts	Door and Window Parts
Clips	Molding	Clutch and Driveshaft Parts
Clamps	Brake Liners	Gaskets
Springs	Cables	Pins
Wire Forms	Transmission Parts	Plastic Extrusions
Cotter Pins	Engine Parts	Rods
Castings	Heater Assemblies	Plastic Water Shields
Decals	Tubing, Rubber	Dies
Headrests	Tubing, Metal	Gears
Interior Trim	Suspension Parts	Bushings
Molding	Mirrors	
Wire Harnesses	Vacuum Harnesses	

Exhibit 5

SMALL METRIC MANUFACTURERS: NUMBER OF EMPLOYEES



Average = 140
Median = 100
Total number of companies = 228

* Number of companies in each category.

** Percentage of total number of companies in each category.

Most of the companies work for more than one of the automakers. For many, the auto industry is their market. The farther away from Detroit, the more likely a company works for industries other than automotive.

Suppliers' Metric Activity

Almost all of the companies contacted supply metric products for Ford. Of the 255 small manufacturers contacted, 17 (7%) supply only customary products to Ford. The 238 (93%) supplying metric products to Ford also supply metric products to the other automakers. The large number of metric small businesses is not surprising, since the team selected the most predominately metric product lines within Ford -- Escort/Lynx and light trucks.

Suppliers to Ford do a substantial portion of their business in metric. The average small firm contacted did half of their work in metric. Similarly, half of the firms contacted did 51% or more of their business in metric. Thirty percent do more than 70% of their business in metric. On the other hand, 24% of the companies contacted were doing less than 20% of their business in metric. Exhibit 6 shows the distribution of metric as percentage of the small companies' total production.

Ford's Role in the Conversion of Small Manufacturers

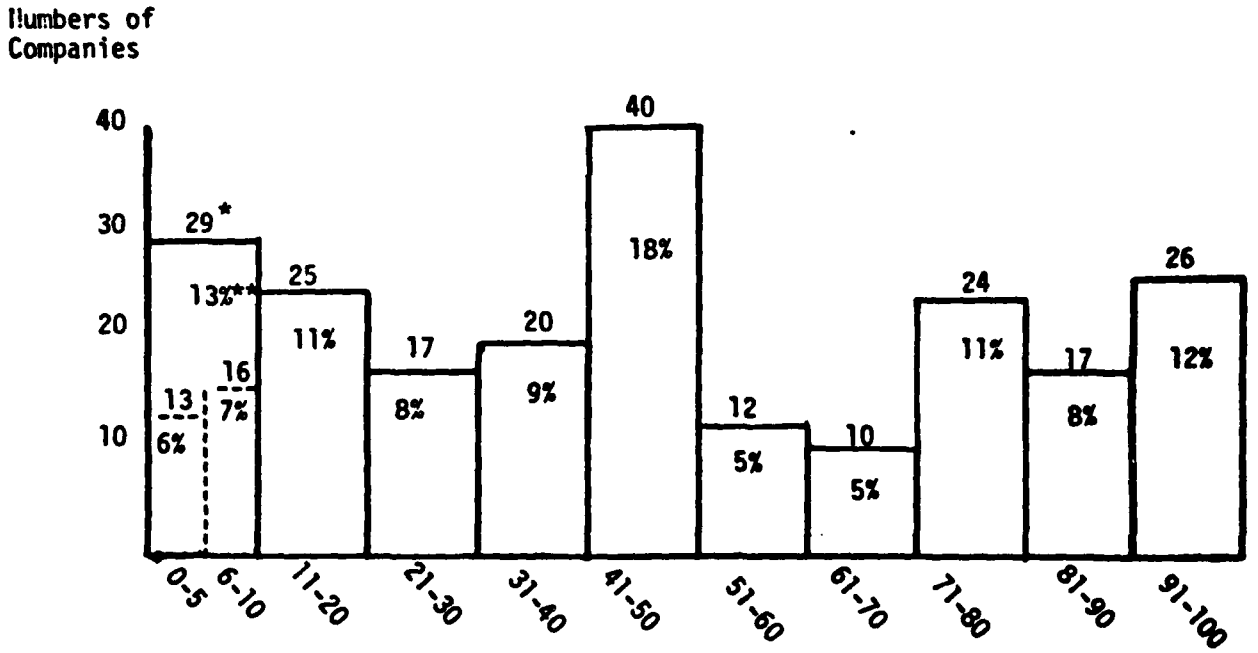
Ford is an important metric customer to most of the small manufacturers contacted. For 10% of the companies, Ford was their sole metric customer. On the other hand, 15% of the companies contacted did less than 10% of their business for Ford. The average company contacted does 43% of its metric work for Ford; half of the companies contacted do 35% or less of their metric work for Ford. Exhibit 7 shows the distribution of small manufacturers' metric production accounted for by Ford.

Do the small manufacturers doing the most metric manufacturing get the majority of Ford's metric business? Exhibit 8 shows that the percentage of a company's production in metric does not determine the percentage of metric work related to Ford. The relationship is strikingly balanced; no one of the 16 cells accounts for more than 12% of the total. Companies with less than 50% of their work in metric and for whom Ford has less than 50% of their metric business account for

Exhibit 6

SMALL METRIC MANUFACTURERS

PERCENTAGE OF TOTAL PRODUCTION IN METRIC

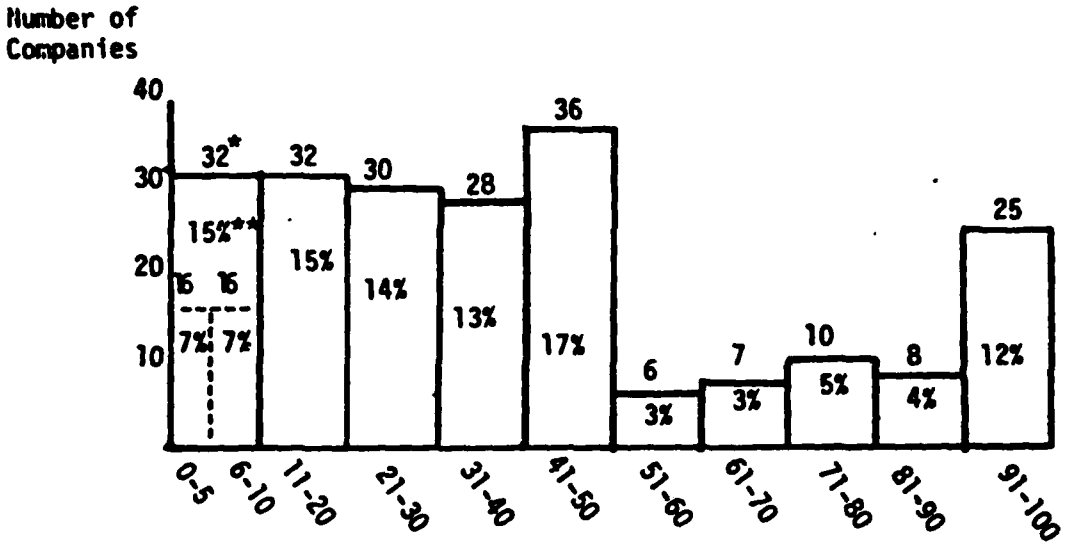


Average = 51%
Median = 50%
Total number of companies = 220

* Number of companies in each category.
** Percentage of total number of companies in each category.

Exhibit 7

SMALL METRIC MANUFACTURERS:
PERCENTAGE OF METRIC PRODUCTION ACCOUNTED FOR BY FORD



Percentage of Metric Production Accounted for by Ford

Average = 43%
Median = 35%
Total number of companies = 214

* Number of companies in each category.

** Percentage of total number of companies in each category.

Exhibit 8

SMALL METRIC MANUFACTURERS:

RELATION OF PERCENTAGE OF METRIC ACCOUNTED FOR BY FORD
WITH PERCENTAGE OF PRODUCTION IN METRIC

Percent of Total Production in Metric	Percent of Metric Production Accounted for by Ford: 0-24%	25%-49%	50-74%	75-100%	Total
0-24%	20 (9%)	8 (4%)	7 (3%)	16 (8%)	51 (24%)
25-49%	18 (8%)	10 (5%)	5 (2%)	7 (3%)	40 (19%)
50-74%	13 (6%)	17 (8%)	15 (7%)	10 (5%)	55 (26%)
75-100%	11 (5%)	25 (12%)	20 (9%)	10 (5%)	66 (31%)
Total	62 (29%)	60 (28%)	47 (22%)	43 (20%)	212 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

27% of the total number of companies. Companies with over 50% of their work in metric and over 50% of their metric work for Ford account for 26% of the total. The fewest companies (16%) fall in the category of less than 50% metric production and over 50% of that production related to Ford. No one company dominates small metric manufacturers supplying Ford. The companies contacted do a substantial amount for metric business but for a number of customers. These other customers are other automakers.

Suppliers' Investments in Metric Production

Ford's suppliers have spent little in converting to metric. Most companies convert metric drawings to customary and use existing equipment. If a company spends anything for metric production, the money goes to quality control equipment.

Of the 238 small businesses supplying Ford with metric products, 86% (205) have spent less than $10,000 converting to metric. Of those 31 companies spending over $10,000, 11 do not consider the investment a significant one for their company. Only 20 (9% of the small manufacturers making metric products) spent over $10,000 and consider the investment significant to the company.*

Suppliers do not invest in metric conversion because they do not work in metric dimensions. Exhibit 9 shows the percentage of companies using four different methods for dealing with metric orders. The largest number of companies (46%) produce metric products using customary dimensions. The smallest percentage (13%) work only in metric. The remaining 41% work in customary and metric - either by producing in customary and inspecting in metric (15%) or by producing some metric products using customary and some metric products using metric (26%).

The method of metric production does not vary with the amount of metric production the company is doing. Exhibit 10 shows the relationship between percentage of total production in metric and the method of metric production. Of those companies with over 75% of their production in metric, the number working in customary is double the number working in metric. Among those companies working in metric, 12 have over 75% of their production in metric; 9 have less than 25% of their production in metric.

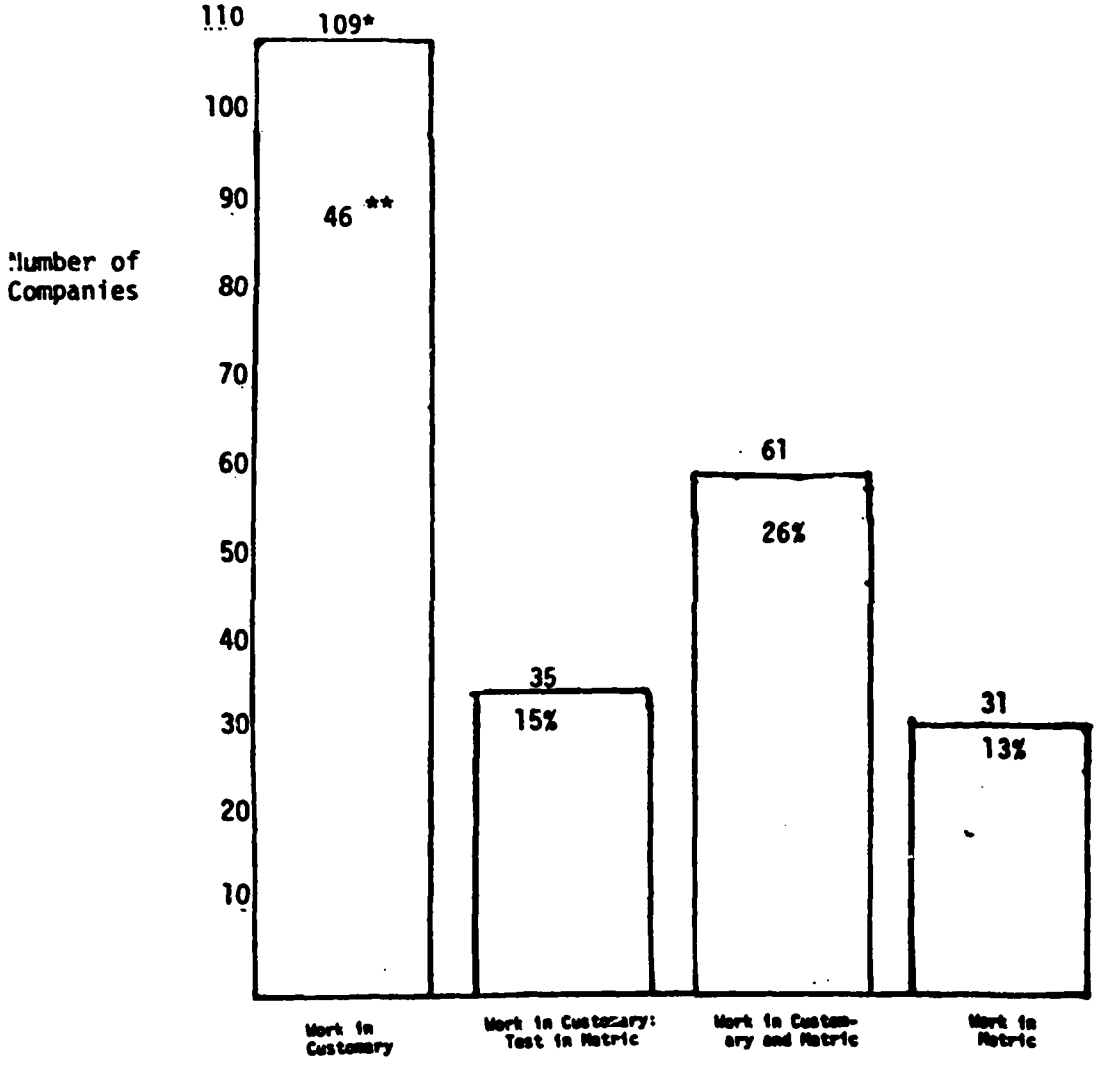
Small manufacturers converting to metric invest in quality control equipment primarily. The most measurement sensitive aspects of production - tooling and fixtures - are paid directly by the customer or indirectly by the

*Two companies have always made metric products so they have not invested in converting to metric.

Exhibit 9

SMALL METRIC MANUFACTURERS

METHOD OF METRIC PRODUCTION



Method of Metric Production

Total number of companies = 236

* Number of companies in each category.

** Percentage of total number of companies in each category.

Exhibit 10

SMALL METRIC MANUFACTURERS:

RELATION OF PERCENTAGE OF TOTAL PRODUCTION IN METRIC WITH METHOD USED IN PRODUCTION OF METRIC PRODUCTS

METHOD

Percent of Metric Production	Work in Customary	Work in Customary: Test in Metric	Work in Customary and Metric	Work in Metric	Total
0-24%	23 (10%)	7 (3%)	17 (8%)	9 (4%)	56 (25%)
25-49%	19 (9%)	11 (5%)	5 (2%)	5 (2%)	40 (18%)
50-74%	28 (13%)	9 (4%)	15 (7%)	5 (2%)	57 (26%)
75-100%	30 (14%)	6 (3%)	19 (9%)	12 (5%)	67 (30%)
Total	100 (45%)	33 (15%)	56 (25%)	31 (14%)	220 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

customer through the piece rate. The small manufacturer only invests in general equipment such as micrometers, height gauges, callipers, scales, and the like. For the small number of manufacturers working in metric, investments include digital readouts and lead screws for lathes. In general, these small manufacturers spend very little converting to metric - often less than $5,000 over the course of several years.

Small metric manufacturers report few problems and few benefits from metric production. Most of the companies contacted did not cite any problems with metric. Those who did mention problems cited inconvenience of converting from one system to the other; a few companies complained about the time they spend converting. Some companies have had temporary increases in mistakes or confusions as a result of conversion. A few mentioned problems finding parts or tools in metric. Many companies referred to the difficulty people on the floor have with metric; most employees do not think in metric and do not want to think in metric. Some observe that this is most true of the older workers.

Suppliers convert to keep the business of current customers. Those few companies that mentioned benefits said conversion allowed them to keep their business. A couple of firms mentioned an increase in business or an increased willingness to work in metric as benefits of conversion.

Small manufacturers respond to metric, like many other problems - when it is time to convert. The problems are so few and the cost so low there is no need to plan. The small manufacturers converting to metric do not need or request assistance from others, according to the companies contacted. It is an insignificant problem - easily handled within the company.

Exhibits 11 and 12 are vignettes depicting experiences of small manufacturers converting to metric without making substantial investments in metric production. One describes investments in production equipment; the other describes the more typical investment in quality control equipment. Do the experiences of the 31 firms reporting substantial investments in metric production differ from those described above? The following section analyzes the metric conversion experiences of these substantial investors.

Exhibit 11

MARBEN CORPORATION: Metric Success Without Cost

Marben Corporation of Jackson, Michigan makes brackets for alternators, steering assemblies, and other components of cars and trucks. Some production runs may be as large as 35,000 to 40,000 pieces a month; other runs (such as for spare parts) may be as few as 400 pieces per month. Marben machines castings to produce brackets; this machining includes drilling, grinding, tapping etc. Exhibit 11A shows the type of products Marben makes. Exhibit 11B shows a casting before and after Marben has worked on it.

Marben is a subsidiary of Teer, Wickwire & Co. Teer, Wickwire & Co. has approximately 250 employees at four divisions; Marben accounts for about 50 of those employees. On October 1, 1981, Simpson Industries, a large company, acquired Teer Wickwire. During the metric conversion experience described below, Marben was a small company.

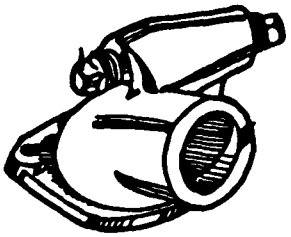
Marben does 35% of its work in metric. All of Marben's metric work is for Ford; Ford accounts for 70% of Marben's total sales dollars.

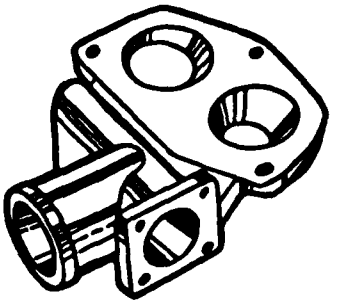
Marben responds to Ford's metric business by converting the drawings to customary dimensions. Marben makes 40% of the tooling it uses. Local tool and die shops are used for more complex tooling jobs. The Marben toolmakers and the outside tool and die shops convert the drawings to customary to produce Ford's metric parts. The toolmaker spends at most 45 minutes converting the drawing for a single job. He may do this once every two months; thus this is an insignificant cost. The primary costs in making Marben's metric products are lead screws for tapping machines, taps, thread gauges, and drills. Most of these costs are borne by Ford either directly or through the piece cost of the part. Ford pays for fixtures, initial gauging, and initial tooling. The quality control people at Marben continue to work in customary so they have not invested in quality control equipment.

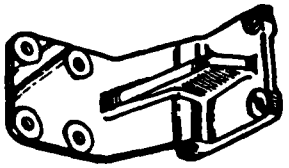
Marben has invested little on metric conversion - much less than $10,000. Their costs have been for lead screws for lathes and possibly some new drill beds. Marben would have paid these costs even if they had been adding new customary parts to their production. Metric is a substantial element of Marben's business. It has not been a substantial cost for Marben. They continue to work in customary. (See Exhibit 11C.)

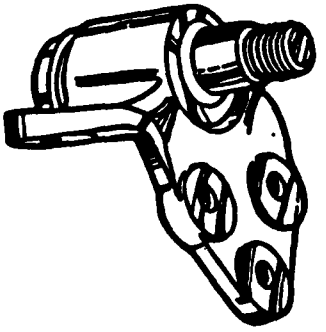
Exhibit 11 A

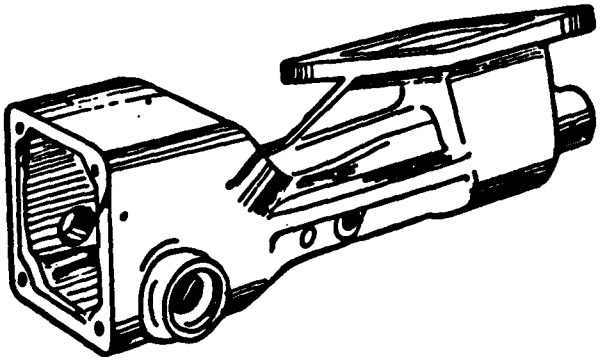
SOME MARBEN PRODUCTS











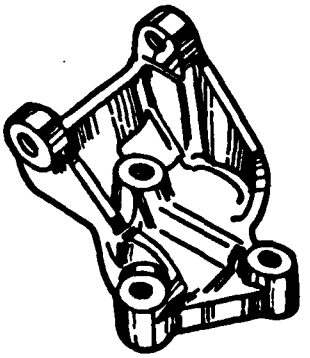


Exhibit 11B

A CASTING BEFORE AND AFTER MARBEN MACHINES IT

Exhibit 11C

A CONVERTED METRIC DRAWING
(The dark numbers in brackets are customary;
All others are metric)

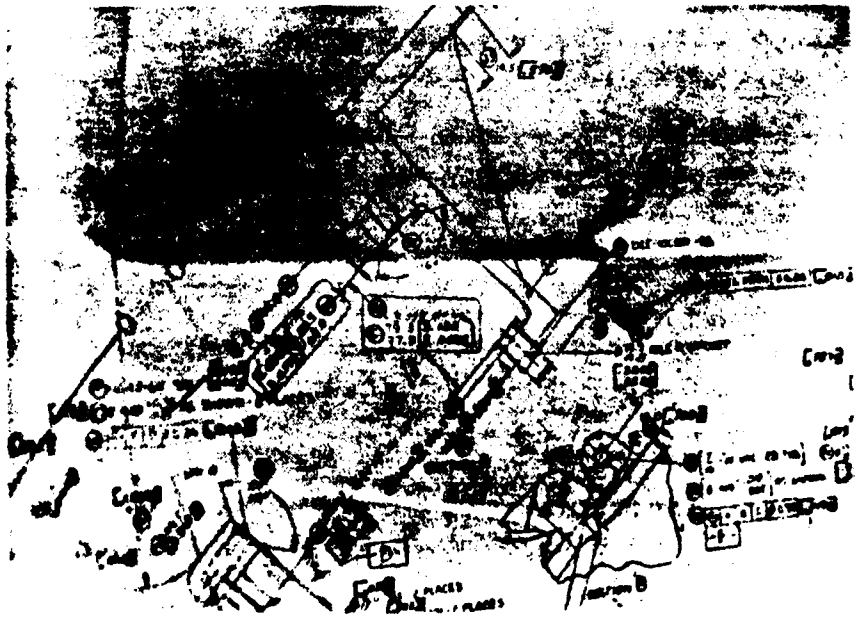


Exhibit 12

DUDEK & BOCK: Producing Quality Metric Products with Little Investment

Dudek and Bock of Chicago, Illinois makes springs, wire forms and metal stampings (See Exhibit 12A). They sell about $20 million annually and have 400 employees. Forty percent of their business is for automotive industry - for the automakers or for companies who do a lot of work for the auto companies, such as Kelsey-Hayes or Bendix. Over half of their automotive work - 25% of their total production - is in metric. Ford accounts for a third of Dudek and Bock's metric work.

Dudek and Bock produce metric products using customary dimensions. They incur minor costs for the time required to convert the drawings from metric to customary. They estimate metric adds 10% to their cost in preparing quotes on auto company parts; the costs of preparing quotes vary, depending on their complexity, between tens and hundreds of dollars. Conversion has also increased the time required to lay out a job and the tooling costs for a job. For example, laying out a customary job might cost $25.00 where laying out the same job in metric would cost $28.00. Most of these costs are passed on to the customer. Because of competitive pricing, some must come out of profit. Dudek and Bock did not estimate how much metric work cost the company in a year.

Recently, Dudek and Bock bought an optical comparator - an inspection machine (See Exhibit 12B) - for $10,000 and spent $10,000 updating another optical comparator. Of this $20,000, $6,000 was related to developing a metric capability for both machines. Over a year, Dudek and Bock may spend $750,000 in capital purchases.

An interesting sidelight: The people working with metric at Dudek and Bock have few problems with linear measurement. When force measurements are used, such as newton meters, confusion increases.

Exhibit 12A

DUDEK & BOCK SPRINGS

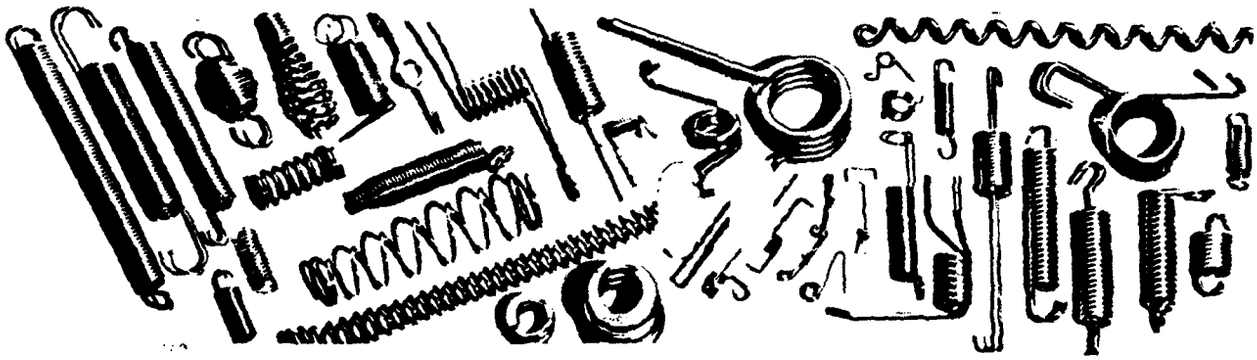
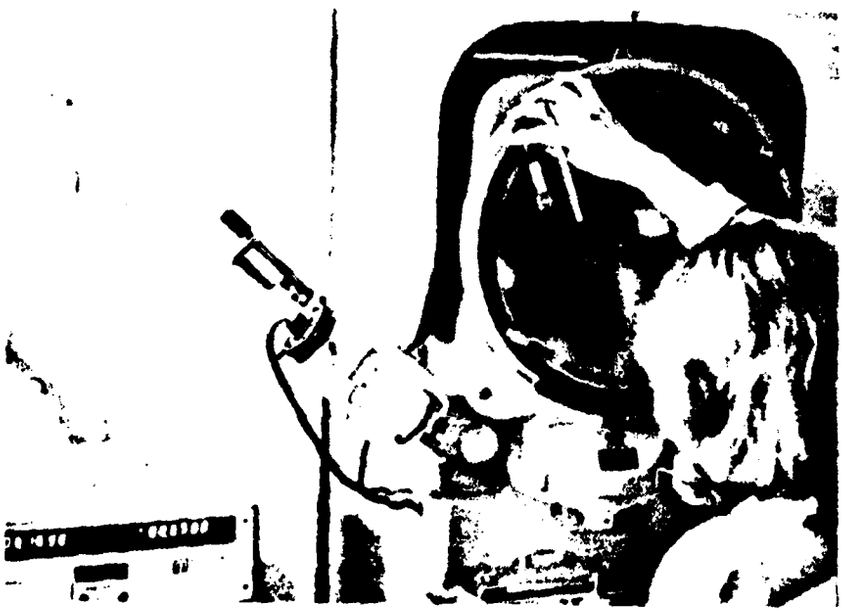


Exhibit 12B

AN OPTICAL COMPARATOR AT WORK



Substantial Investors

Thirty-one of the 238 small metric manufacturers spent more than $10,000 converting to metric. Of these 31, 11 do not consider the investment a significant expense for the company. Most of these 11 companies spent between $10,000 and $20,000 on quality control equipment and upgrading production equipment (usually digital readouts). They have spent that sum over 3-5 years. Over the same period, many of these companies have invested $500,000 in new capital equipment. Relative to their capital investment, the companies judge the investment in metric conversion insignificant. Exhibits 13 and 14 illustrate the experiences of the substantial investors who do not consider their investment significant; one company produces metric fasteners; the other makes metric metal stampings.

Substantial Investors Considering Their Investments Significant

The twenty firms who report over $10,000 dollars spent on metric have similar characteristics to the insubstantial investors. The average substantial investor who considers the investment significant is slightly larger than the average small metric manufacturer. It has 160 employees; compared to the overall average of 140. Half of these substantial companies have 150 employees or fewer (see Exhibit 15). The substantial investors primarily making stampings, fasteners, and plastic molded parts. They are located mostly in Michigan, Illinois, Indiana, and Ohio.

Companies who consider their investment in metric production significant do not differ from other small metric manufacturers in terms of percentage production in metric. The average for the 20 significant investors is 51%; it is the same for all small metric manufacturers. Half the substantial investors have no more than 40% of their production in metric (see Exhibit 16); 41% of all small metric manufacturers have no more than 40% of their production in metric (see Exhibit 6, p. 28).

EXHIBIT 13

MIDWEST FASTENER CORPORATION: Metric Quality - a Routine Cost

Midwest Fastener Corporation of South Holland, Illinois makes fasteners - primarily self threading screws. See Exhibit 13A. Midwest Fastener has 100 employees. Most of their work is for the automotive and appliance industries. Automotive accounts for 60% of their sales and of that 60%, 80% is metric. Thus, 48% of Midwest Fastener's business is in metric and all of that is accounted for by automotive.

Midwest Fastener continues to produce its metric products using customary dimensions. For many of their fasteners, the major, minor, and pitch diameters are of greatest significance (See Exhibit 13B). The tolerances on most metric drawings allow them to use a customary size that will fit the metric requirement. When they work with more precise machine screws, then they do buy metric tooling to make screws. Midwest Fastener is one of the largest users of metric tooling in their area; of the $34,000 a month they spend on tooling, they estimate they spend a $3,000 premium for metric tooling. These costs are passed on to the customer in the piece rate.

Direct costs for metric conversion by Midwest Fastener include between $10,000 and $20,000 on quality assurance equipment. Most of this - $9,000 - was for thread ring gauges for checking screws. They have also bought new jigs for testing tensile strength, and new penetration gauges.

This is a one-time investment as the metric fasteners replace old inch series of fasteners. Their sales are about $12 million a year; they may spend $250,000 a year on new capital equipment. Metric has cost them less than 5% of their annual capital investment over 5 years. Metric has not eaten into their profits - most of the costs are passed on to the customer. Midwest Fastener considers the costs that they have borne insubstantial.

Exhibit 13A

MIDWEST FASTENER'S PRODUCTS

SEMS WASHER ASSEMBLIES

Fasteners with free spinning non-removable washers.

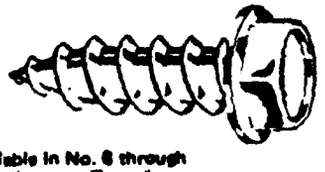
THREAD-CUTTING

Thread-cutters No. 6 through 3/8" diameter. Type 1, 23, 25, 17 and F.

SPECIALS

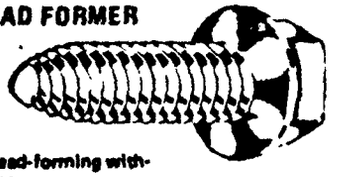
Fasteners and parts custom-made formed to your design specifications.

TAPPING SCREWS



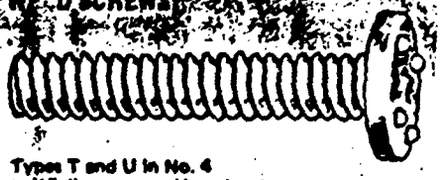
Available in No. 6 through 3/8" diameter. Type A, B and AB.

TRIANGULAR POINT THREAD FORMER



For thread-forming without chips.

WELD SCREWS



Types T and U in No. 4 to ½" diameters and lengths 5/8" to 8".

MACHINE SCREWS & BOLTS

In all metals - No. 5 to 5/8" diameters and lengths 3/16" to 5".

Exhibit 13B

MAJOR AND MINOR DIAMETERS

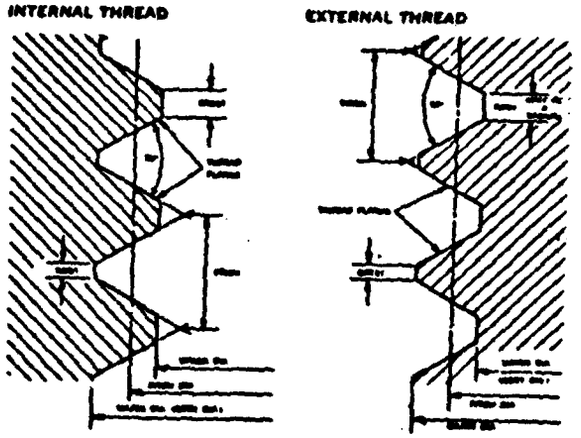


Exhibit 14

ANDERSON BOLLING: Investment in Quality Pays Off

Anderson-Bolling of Grand Haven, Michigan makes stampings for carburetors, manifolds, heaters, and other car and truck parts. Most of their work is for the automotive companies; some is for appliance manufacturers. They sell up to $40 million a year and have over 250 employees. Half of their work is to metric dimensions; 50% of their metric work is for Ford.

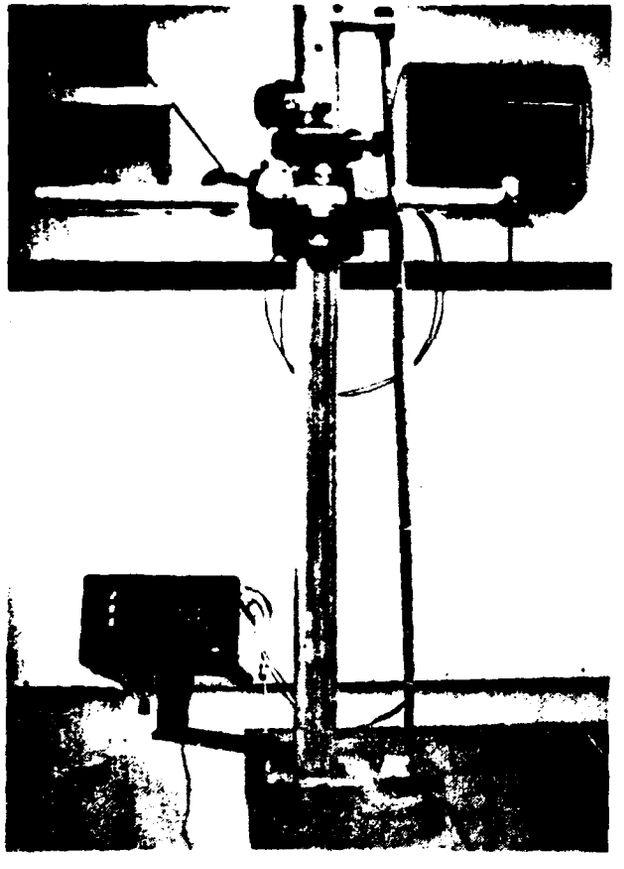
Anderson Bolling works in customary on the factory floor. They make some of their own tooling; some is made by outside contractors. The company toolmakers and the outside tool and die shops make the metric tools using customary dimensions.

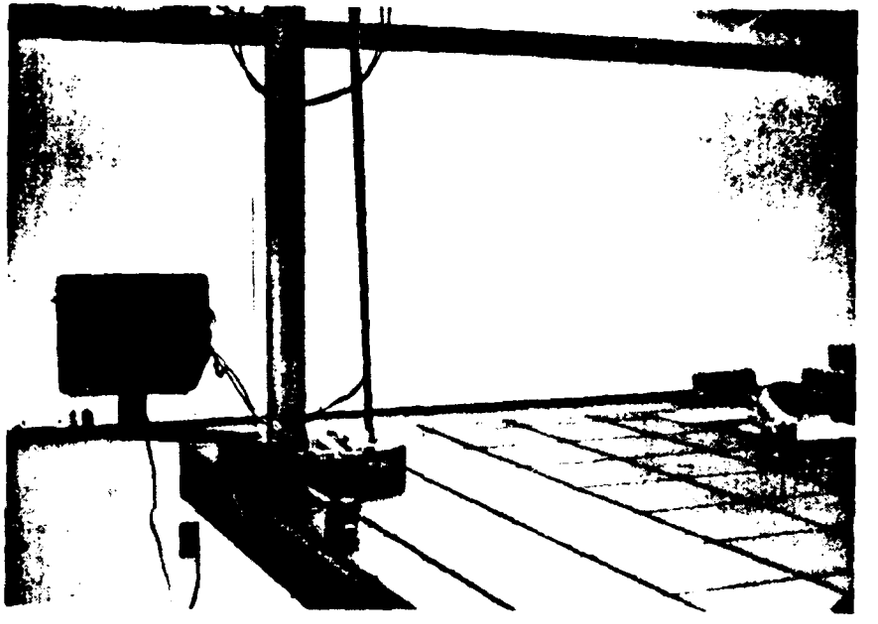
Their primary investment is in quality control equipment. Several years ago the company upgraded its quality control equipment. At that time, the quality control manager argued they should invest in converting their portage machines - inspection tables used for measuring in three dimensions (See Exhibit 14A). To outfit both of their portage machines so they could work in metric cost $20,000. In addition, they spent $5,000 on other quality assurance equipment. The quality control manager justified this cost with the estimated time savings. He judged it took three times as long to inspect a metric part on a customary portage table as it did a metric table. The manager of the plant estimated that the portage machines paid for themselves in 6 to 8 months from these time savings.

Anderson Bolling spends several million dollars over five years on upgrading their capital equipment. The $25,000 investment in quality assurance equipment for metric is a drop in the bucket according to them.

Exhibit 14A

A PORTAGE MACHINE



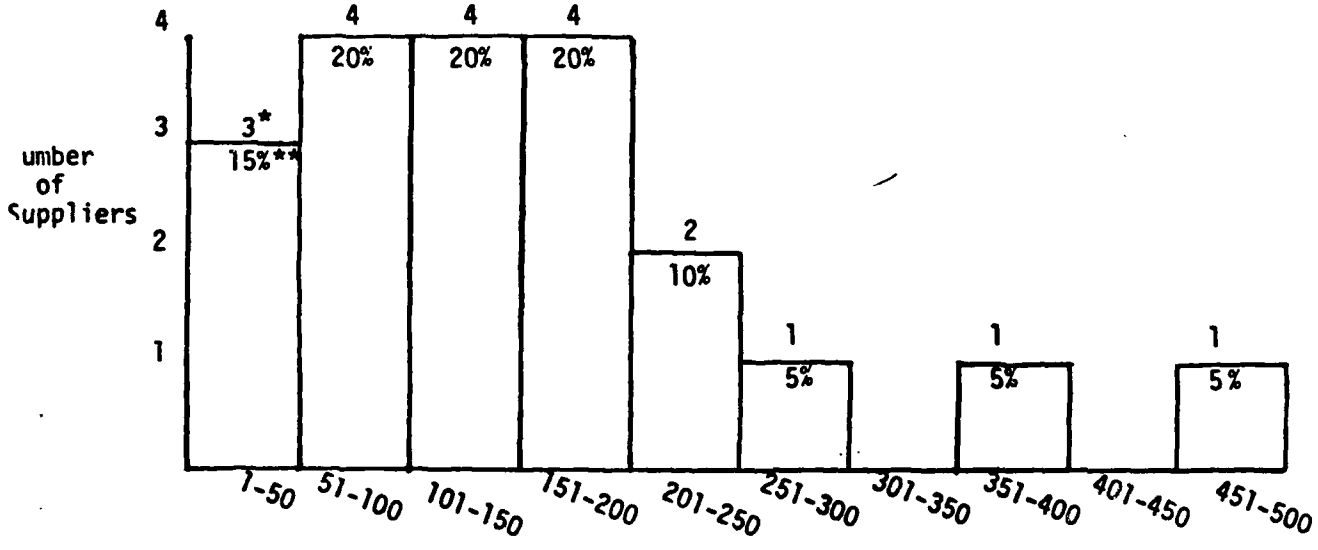


Ford

Exhibit 15

SMALL METRIC MANUFACTURERS WITH SIGNIFICANT INVESTMENTS IN METRIC PRODUCTION

NUMBER OF EMPLOYEES



Average = 168
Median = 150
Total number of companies = 20

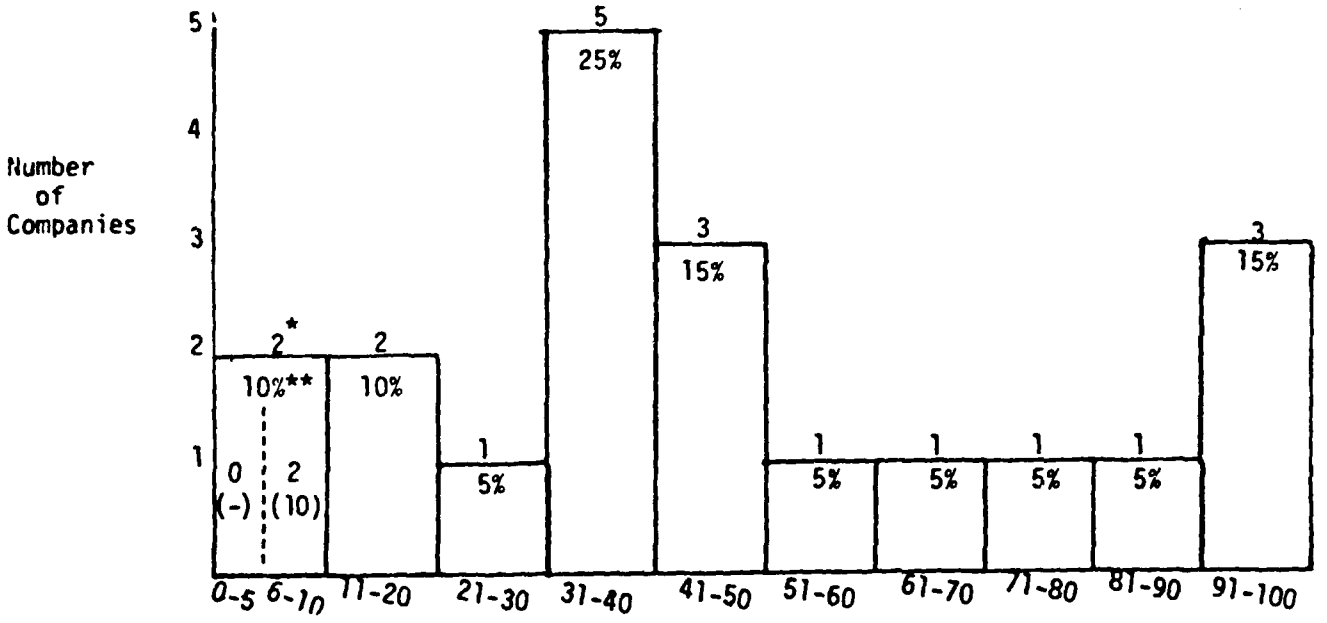
* Number of companies in each category.

** Percentage of total number of companies in each category.

Exhibit 16

SMALL METRIC MANUFACTURERS WITH SIGNIFICANT INVESTMENTS IN METRIC PRODUCTION

PERCENTAGE OF TOTAL PRODUCTION IN METRIC



Percentage of Total Production in Metric

Average = 51%

Median = 40%

Total number of companies = 20

* Number of companies in each category.

** Percentage of total number of companies in each category.

Substantial investors who consider their investment significant do less of their metric work for Ford than the insubstantial investors. Exhibit 17 shows the distribution of percentage of metric accounted for by Ford. The average substantial investor does 35% of its metric work for Ford; the average small manufacturer does 43% of its metric work for Ford. Ford is clearly not the driving force behind the substantial investments in metric production. Exhibit 18 shows the relationship between the percentage of production in metric and the percentage of metric production related to Ford for substantial investors. As in the case of all small metric manufacturers, there is little relationship between the two.

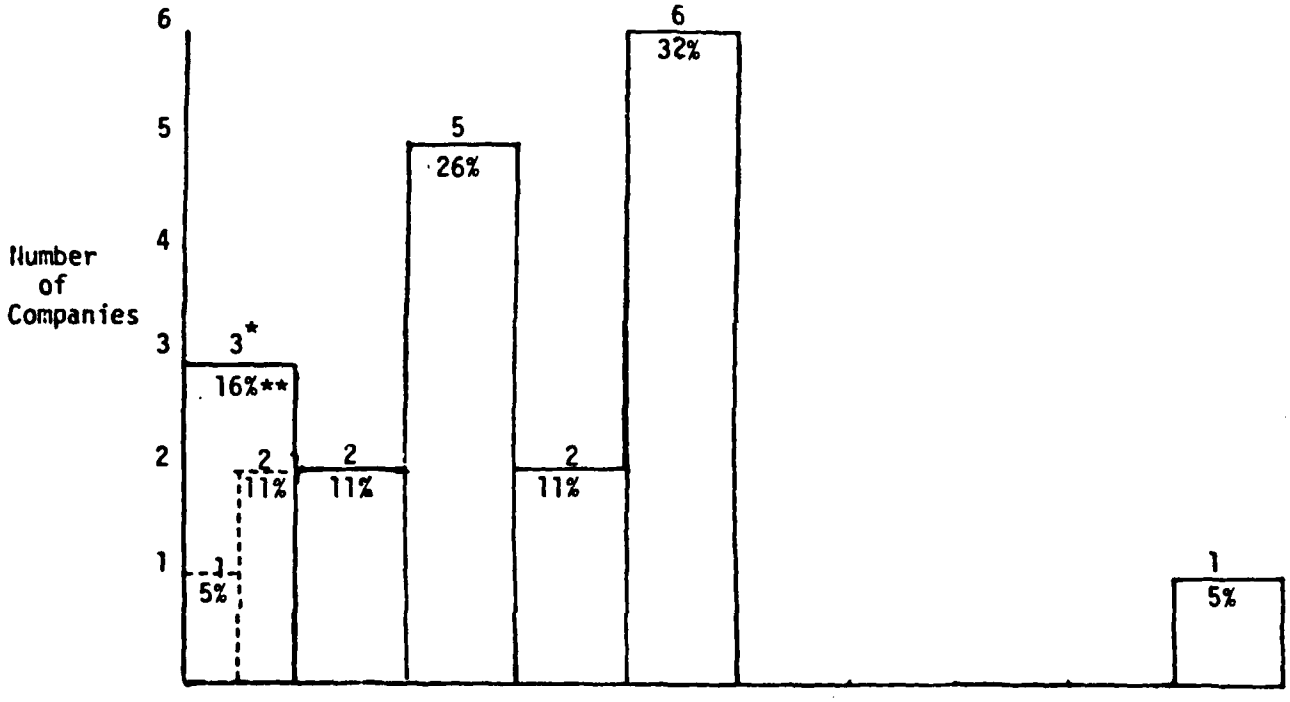
The method of producing metric products does not account for the difference between substantial investors and all small metric manufacturers. Exhibit 19 shows the number of substantial investors working in the different methods. There is a slightly greater tendency for the substantial investors to work in metric or in metric and customary; only 2 work only in customary. For substantial investors the method of metric production differs slightly depending on the percentage of metric production (See Exhibit 20). Of the 11 companies with less than 50% of their work in metric, 5 continue to work in customary, or work in customary and inspect in metric. Of the 9 companies with over 50% of their production in metric, only one company works in customary and tests in metric. Four work in metric and customary; four work in metric alone. These slight differences between the substantial investors and the small metric manufacturers in general on the method of producing metric do not fully explain the difference in investment.

Why do some companies make substantial investments in metric production? Most of some substantial investments in metric are between $10,000 and $20,000. In every case, the investment involves additional quality control equipment and upgrading of production machinery. Exhibits 21, 22, and 23 describe small manufacturers who made such investments in quality control and production equipment and consider the investment significant.

Exhibit 17

SMALL METRIC MANUFACTURERS WITH SIGNIFICANT INVESTMENTS IN METRIC PRODUCTION:

PERCENTAGE OF METRIC PRODUCTION ACCOUNTED FOR BY FORD



Percentage of Metric Production Accounted for by Ford

Average = 35%

Median = 30%

Total number of companies = 19

* Number of companies in each category.

** Percentage of total number of companies in each category.

Exhibit 18

SMALL METRIC MANUFACTURERS WITH SIGNIFICANT INVESTMENTS IN METRIC PRODUCTION

RELATION OF METRIC ACCOUNTED FOR BY FORD WITH PERCENTAGE OF PRODUCTION IN METRIC

Percent of Metric Production Accounted for by Ford

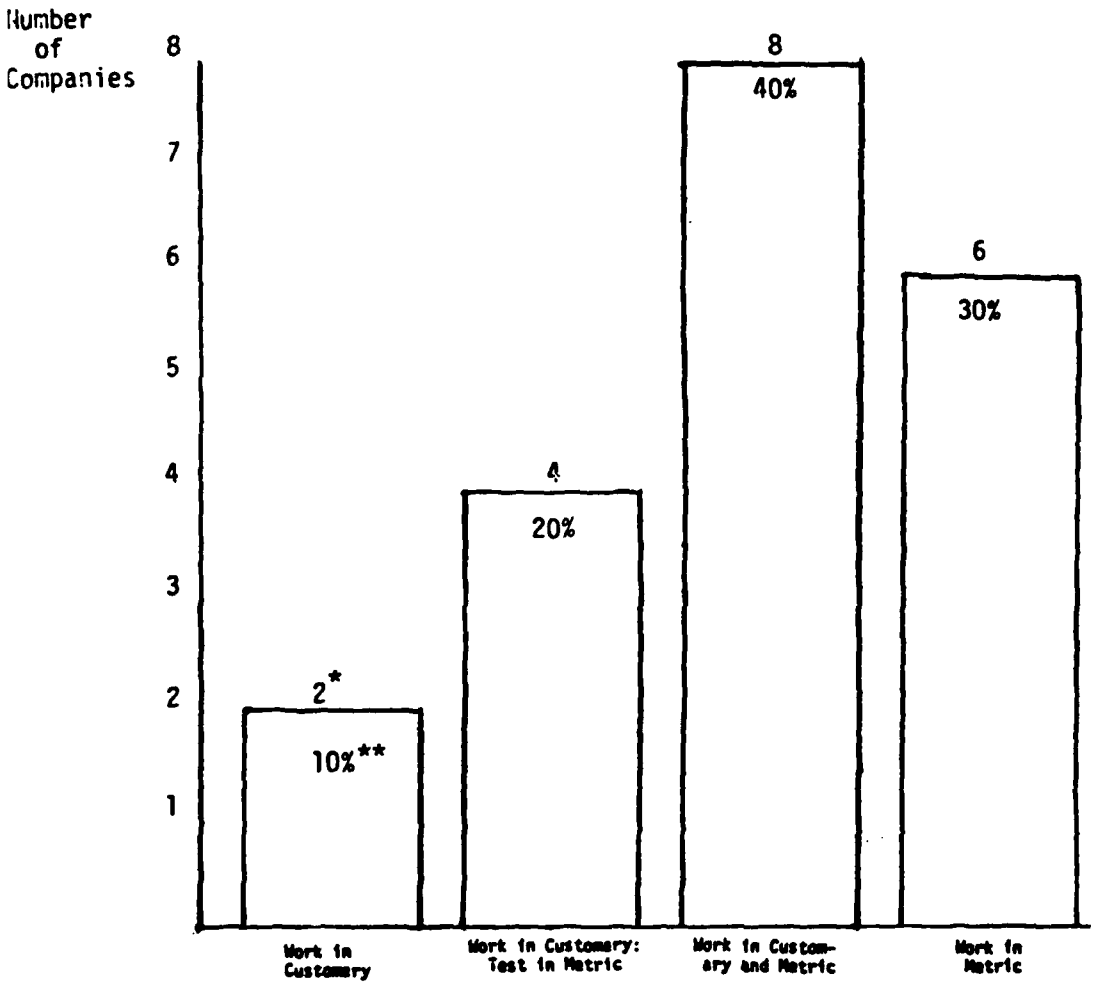
Percent of Total Production in Metric	0-24%	25-49%	50-74%	75-100%	Total
0-24%	0 (0%)	2 (11%)	1 (5%)	0 (0%)	3 (16%)
25-49%	3 (16%)	3 (16%)	1 (5%)	0 (0%)	(7%) (37%)
50-74%	1 (5%)	1 (5%)	2 (11%)	0 (0%)	4 (21%)
75-100%	1 (5%)	1 (5%)	2 (11%)	1 (5%)	5 (26%)
Total	5 (26%)	7 (37%)	6 (32%)	1 (5%)	19 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

Exhibit 19

SMALL METRIC MANUFACTURERS WITH SIGNIFICANT INVESTMENTS IN METRIC PRODUCTION

METHOD OF METRIC PRODUCTION



Method of Metric Production

Total number of companies = 20

* Number of companies in each category.

** Percentage of total number of companies in each category.

Exhibit 20

SMALL METRIC MANUFACTURERS WITH SIGNIFICANT INVESTMENTS IN METRIC PRODUCTION

RELATION OF PERCENTAGE OF TOTAL PRODUCTION IN METRIC WITH METHOD USED IN PRODUCTION OF METRIC PRODUCTS

METHOD

Percent of Metric Production	Work in Customary	Work in Customary: Test in Metric	Work in Customary and Metric	Work in Metric	Total
0-24%	0 (0%)	0 (0%)	3 (15%)	1 (5%)	4 (20%)
25-49%	2 (10%)	3 (15%)	1 (5%)	1 (5%)	7 (35%)
50-74%	0 (0%)	0 (0%)	3 (15%)	1 (5%)	4 (20%)
75-100%	0 (0%)	1 (5%)	1 (5%)	3 (15%)	5 (25%)
Total	2 (10%)	4 (20%)	8 (40%)	6 (30%)	20 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

Exhibit 21

STERLING PLASTICS: Molding a Metric Future

Sterling Plastics of Sterling Heights, Michigan, makes injection molded plastic parts. All of their metric work is for the auto companies; metric accounts for 60% of their total production. Ford is responsible for 50% of Sterling's metric work. They have 120 employees.

Sterling Plastics works in customary and in metric dimensions. Some of their tool shops work in metric, the rest work in customary. The people on the factory floor work in customary. (See Exhibit 21A.) Quality control works in metric on metric parts. Meeting foreign and domestic automakers' needs has meant working more and more to metric specifications.

Sterling's expenses for metric conversion have been in quality control equipment. They purchased a new optical comparator with a metric capability (see Exhibit 21B). The marginal cost for the capability was several thousand dollars. They also spent about $5,000 on developing a metric capability for their X, Y, Z table - a three dimensional testing table (see Exhibit 21C). In addition, they have spent several thousand dollars on callipers, micrometers, and height gauges to work on metric parts.

The investment in metric for Sterling Plastics is considered a substantial expense for the company. They have benefited from the expense in saving time on checking metric parts. The development of their metric capability helped them expand their foreign business as well as keep their existing customers.

Exhibit 21A

STERLING PLASTICS' PLANT

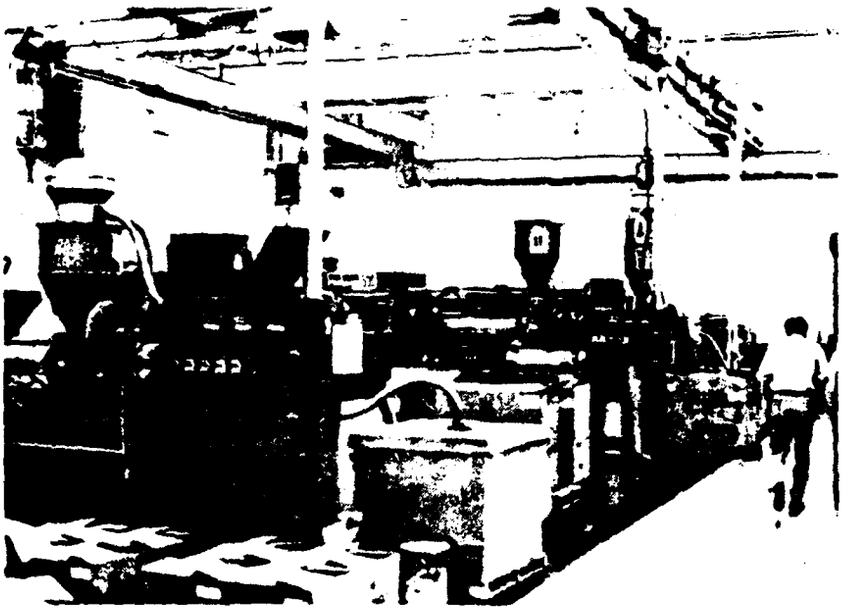


Exhibit 21B

AN XYZ MACHINE

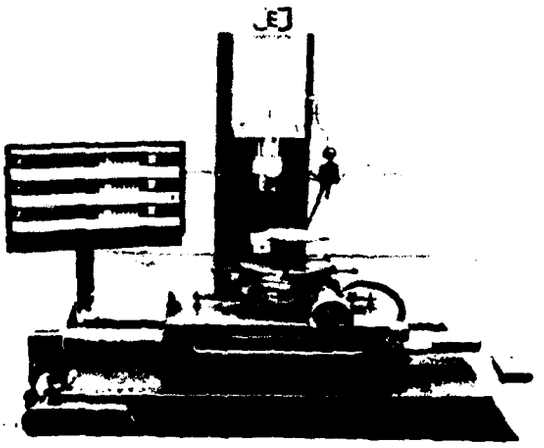
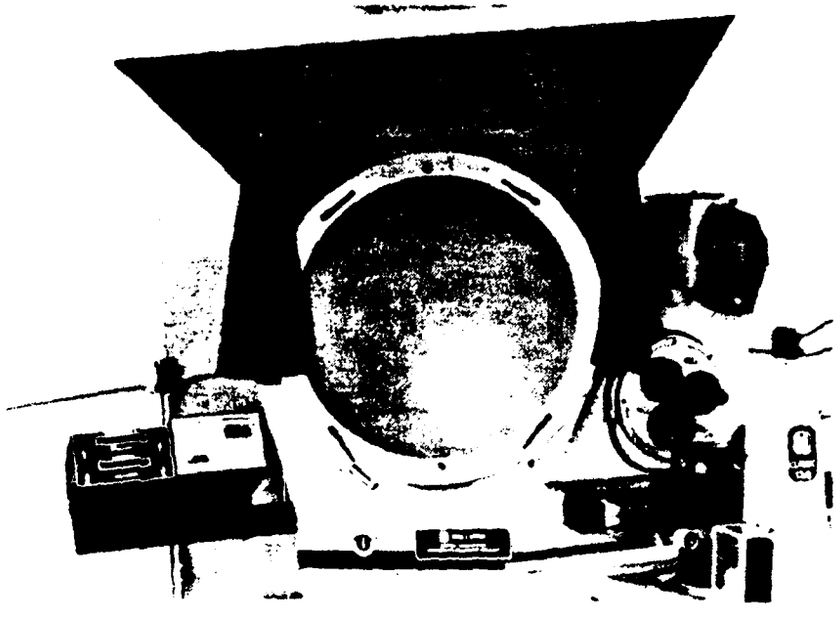


Exhibit 21C

AN OPTICAL COMPARATOR WITH DUAL DIGITAL READOUT



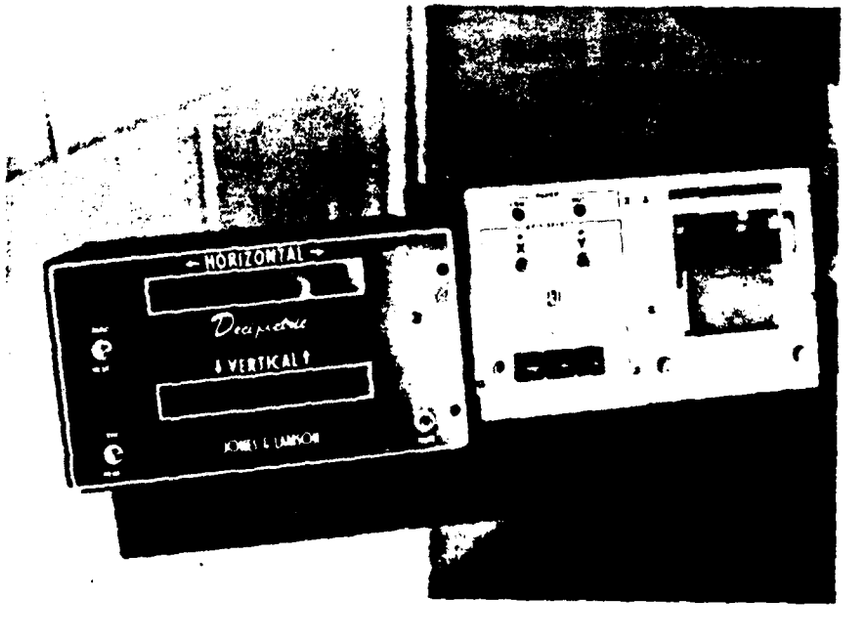


Exhibit 22

NYLONCRAFT: Metric Quality and Production Takes Time

Nyloncraft of Mishawaka, Indiana makes plastic injection molded parts. See Exhibit 22A. They make custom parts for the automotive, plumbing, housewares, appliances, and other industries. About 90% of their business is in metric; of that 30% is related to Ford.

Nyloncraft makes metric products using customary and metric dimensions. They have invested several thousand dollars in adding digital readouts to milling machines and purchasing lathes with metric capability. See Exhibit 22B. They made most of that investment in the middle 1970's when they anticipated a major increase in metric business. The volume has not been as much as they expected. As a result they make most of their tooling by converting from metric to customary.

Nyloncraft has also invested several thousand dollars in new quality control equipment. These include height gauges, readouts for optical comparators, callipers, micrometers, and other instruments. See Exhibit 22C. Overall, they spent around $10,000 developing their metric capability. They consider the investment a substantial one for the company.

In converting from metric to customary, Nyloncraft also invests a person's time. The layout man - the person responsible for laying out the steps for producing the product - invests the most time. A straightforward drawing might take the layout man 20 minutes to convert (see Exhibit 22D); a drawing with 200 dimensions and multiple views might take as many as two hours to convert. The average time for converting was estimated at half an hour a drawing. Nyloncraft gets about 200 new metric jobs a year. If the layout man's time is worth $15 an hour (including fringe and overhead) this works out to about $1500 a year to convert drawings from metric to customary. Compared to the costs of outfitting the floor to work in metric, Nyloncraft considers this cost of conversion reasonable.

Exhibit 22A

SOME NYEOCRAFT PRODUCTS

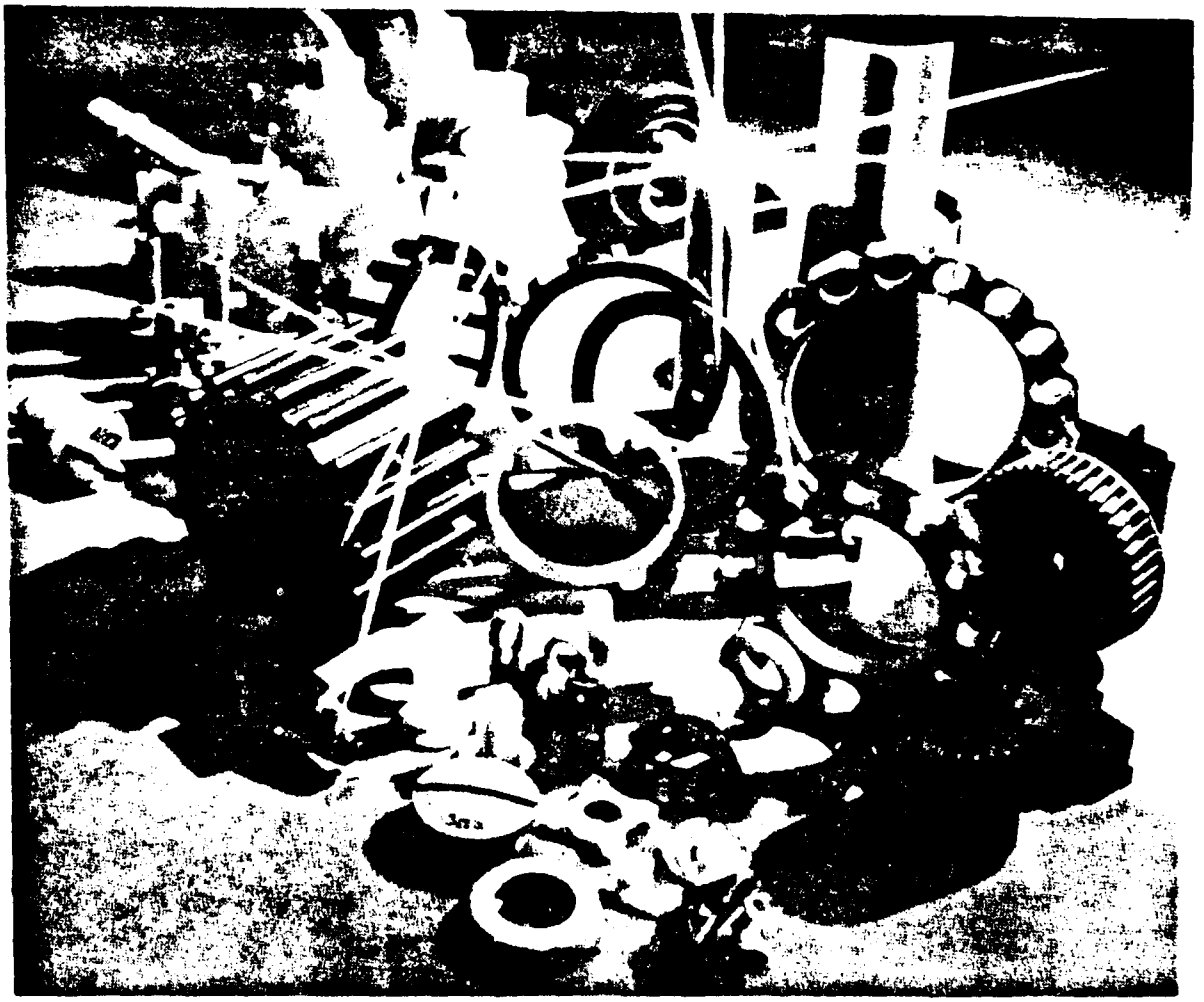


Exhibit 22B

A MILLING MACHINE WITH DUAL DIGITAL READOUT

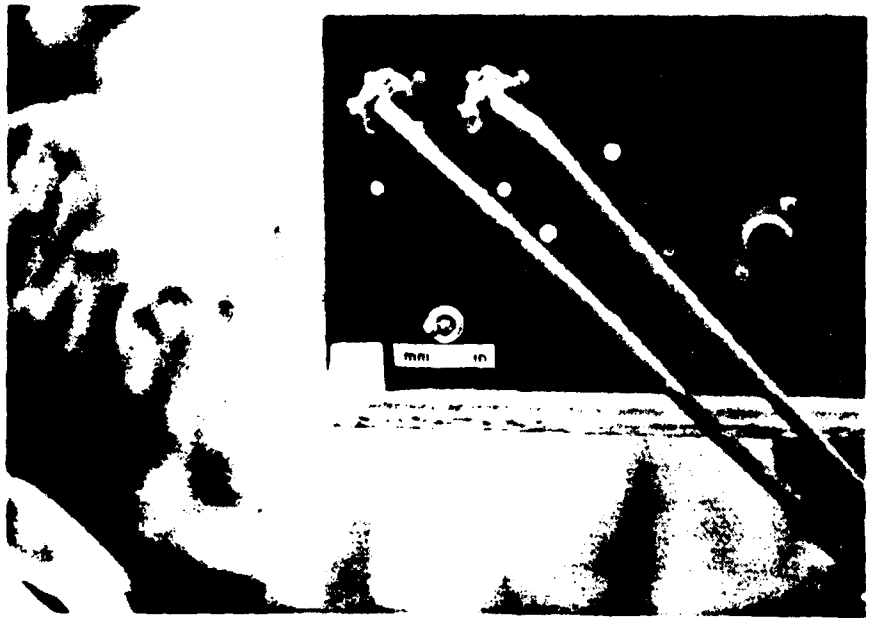


Exhibit 22C

AN OPTICAL COMPARITOR

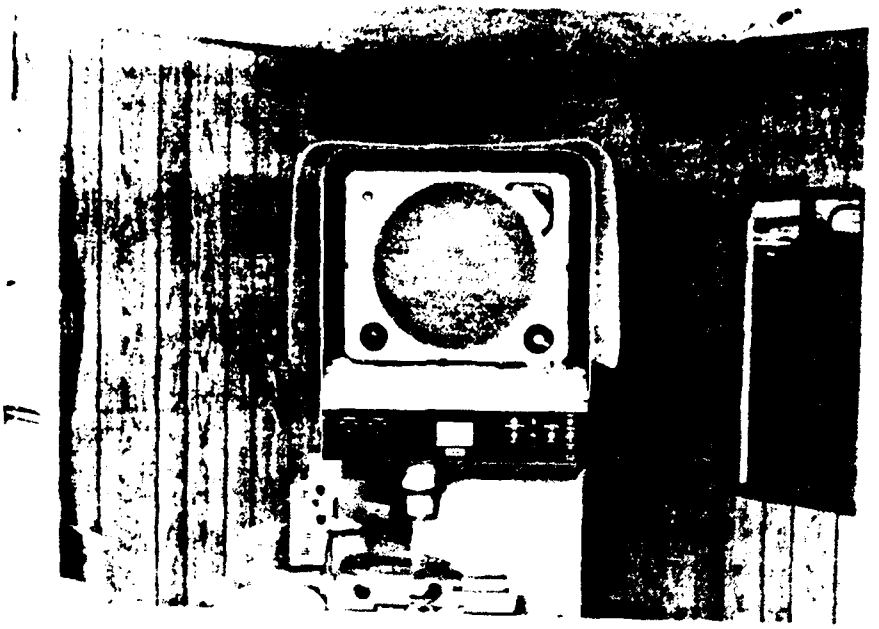


Exhibit 22D

A TYPICAL DRAWING

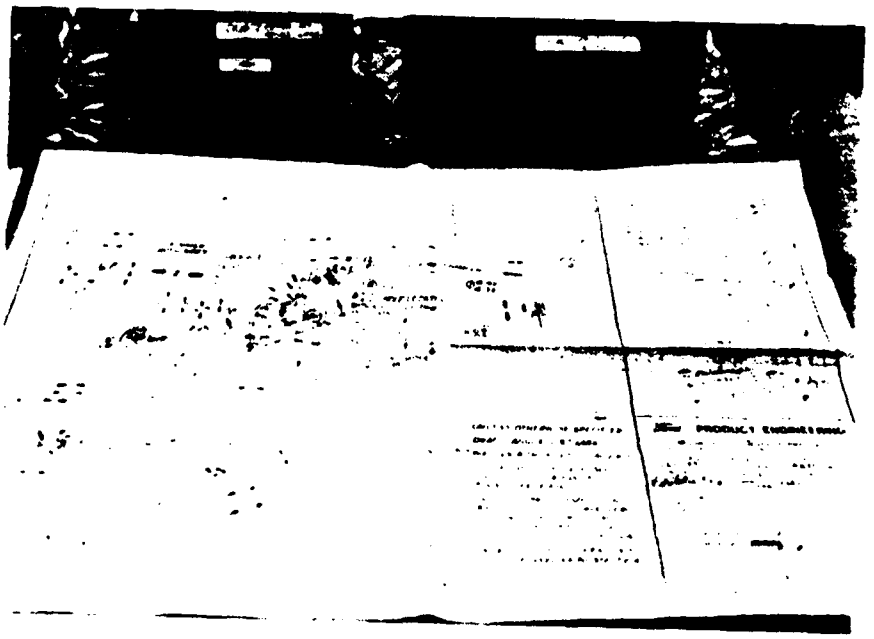


Exhibit 23

NASSAU MACHINE PRODUCTS COMPANY: Machine Shop Metric Production

Nassau Machine of Warren, Michigan makes screw machine parts - nuts, screws, washers (see Exhibit 23A). They employ 10 people. Forty percent of their work is in metric. Five years ago they did not do any metric work. All of their metric work is related to the auto industry; half of their metric work is for Ford.

Nassau Machine works in customary units to the extent possible. When they get a drawing, they convert it to customary. They might spend as much as an hour some days converting from metric to customary to either bid on an automotive job or to set up production for the floor.

The major costs for Nassau's conversion have been for thread gauges and roll dies for making metric threaded fasteners (see Exhibits 23B and 23C). Ford does not pay their tooling costs. They prefer to own their own tooling so they can sell their products to a variety of customers. The metric roll dies cost 30% to 40% more than standard roll dies. They must get 10 sets each for 2 machines. They had to buy all the dies to insure that they could meet the needs of the customer in timely fashion. A major selling point of a small machine shop such as Nassau is response time. They cannot afford the time required to special order thread gauges or roll dies.

Overall, Nassau has spent $15,000 to $20,000 converting to metric. They estimate they pass some of this on to customers over the years. About 20% is paid by the customer for whom they buy the tooling initially. The investment is substantial for a company that spends less than $20,000 a year on new capital equipment.

Exhibit 23A

NASSAU PLANT AND PRODUCTS

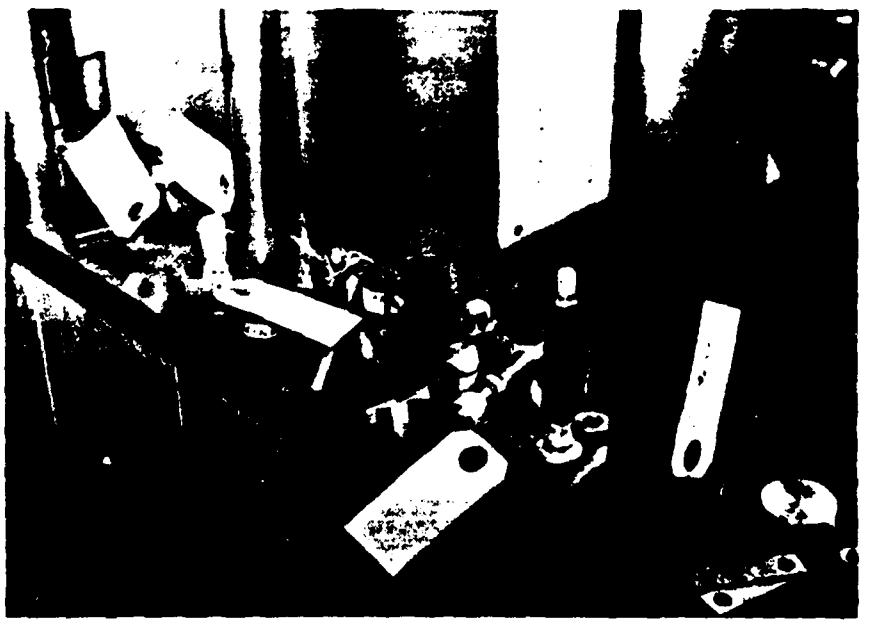


Exhibit 23B

ROLL DIES

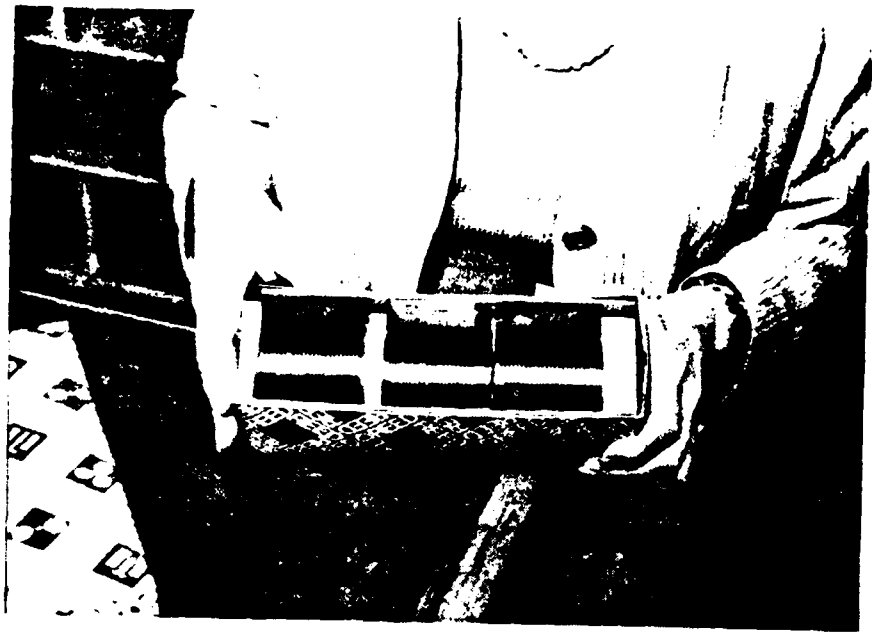
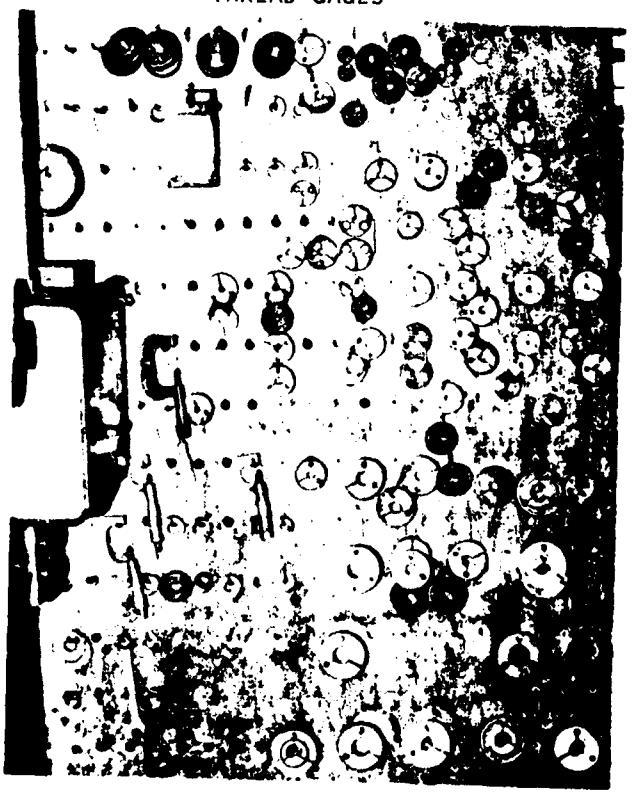


Exhibit 23C

THREAD GAGES



Five companies spent over $60,000 converting to metric. In each case, the company decided to buy its own metric tooling so it could develop its own proprietary line of metric products. Exhibits 24 and 25 are the stories of the two companies that spent the most among those we contacted - a fastener manufacturer and a stamping company. In both cases they made substantial investments - $100,000 - in metric related tooling. To maintain their flexibility, these companies decided to make the tooling investment themselves and develop a new line of metric products.

The substantial investors in metric report the same problems and benefits from conversion as the insubstantial investors. The only difference is a greater tendency to see both problems and benefits. The substantial investors have problems with time for converting, worker resistance, and initial mistakes and confusion. A few of the larger investors commented on the need for more standardization across the different automakers - especially regarding fasteners. This uncertainty is costing them money because they must stock more tools in order to be able to respond quickly to the customer's needs. Ford uses the well-developed ANSI B-18 metric fastener standards for all vehicle metric fastener applications. The Ford Standard Parts Manual is distributed to suppliers on a subscription basis.

On the benefits of conversion, most of the substantial investors saw they had little choice. The industry was going metric. If they wanted to keep or expand their business with the industry, they would have to change with it. They did not foresee great problems in changing, so they did not seek assistance.

Summary: Production Parts Suppliers

Most production parts suppliers made insubstantial investments in converting to metric. Yet, they do an average of half of their work in metric. The minor costs of conversion are for quality control equipment. Substantial investors who consider their investment significant do not differ very much from small metric manufacturers in general. They tend to be slightly larger, do less of their metric work for Ford, and do work in customary and metric, or only in metric. For those investors spending over $50,000 on metric production, the investments result from the company's desire to increase its flexibility in marketing metric products.

Exhibit 24

PROGRESSIVE STAMPING: Big Investment, Big Savings

Progressive Stamping of Royal Oak, Michigan is a high volume flat blank stamper. They make flat metal products including washers (Exhibit 24A). They sell $8 million a year and have 32 employees. Progressive Stamping has been working in metric for four years. At present, 95% of their production is metric; of that Ford accounts for 27%. The rest is for other auto companies, including foreign auto companies.

Progressive works primarily in customary units on the floor. However, they have made a substantial investment in dies for making metric parts. They estimate they have spent $100,000 in new dies for metric parts - 10 dies at an average of $10,000 each. They did not pass these costs on to their customers as tooling costs because they view the tools as company assets. They want to use them to sell metric products to other customers.

Progressive Stamping invested in metric dies to cut the amount of scrap metal when producing metric products. When using a customary die to make a metric product, they had to use a die one size larger than the metric size and cut it down to meet the metric specifications. By working directly in metric, Progressive reduced their scrap and thereby reduced their material costs. According to Progressive, their success depends on reducing materials costs - especially given 7 steel price increases in the last 7 years.

The company recoups some of the cost of the dies but not all of it from their customers. The market is too competitive to pass all of it on. Progressive considers the investment substantial. Progressive feels some of it may have been unnecessary; the lack of standards among the automakers on fasteners creates uncertainties about the preferred metric sizes. This leads to purchasing tools that may never be used in order to be able to respond to the demand should it arise.

Exhibit 24A

PROGRESSIVE'S PRODUCTS

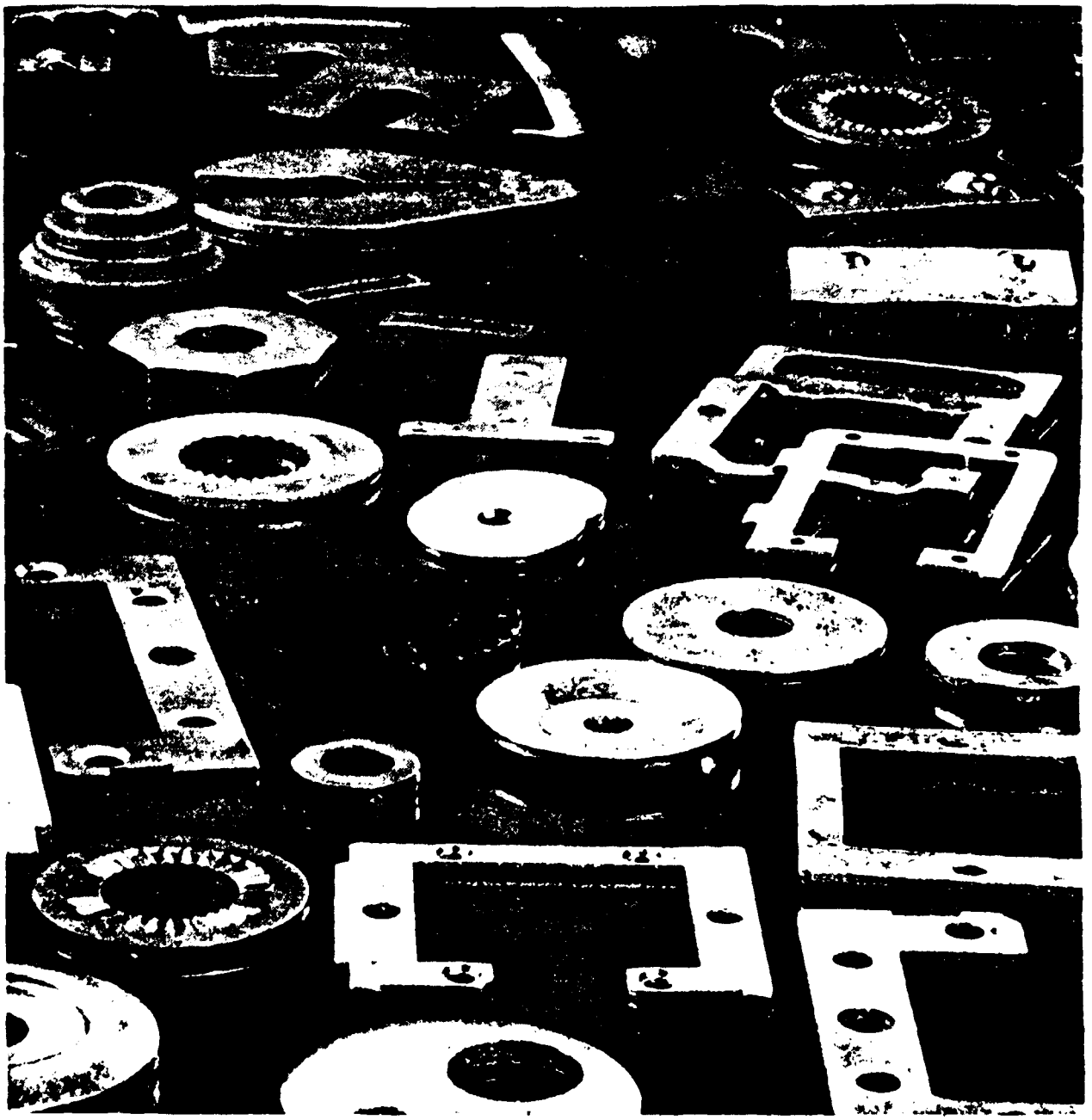


Exhibit 25

MacLEAN-FOGG NUT: Making Metric Nuts

MacLean-Fogg Nut of Mundelein, Illinois makes lock nuts (see Exhibit 25A). They have 150 employees. About 20% of their work is in metric dimensions; 50% of that metric work is related to Ford Motor Company.

MacLean-Fogg made a major investment in metric conversion - $200,000 - several years ago. They saw a growing automotive market for metric fasteners and decided they would develop their own line of fasteners to meet this demand. They spent $10,000 on the research and design of the fastener line; $50,000 for new metric feeder lines for the production machines; $100,000 for tooling to make the new line of fasteners; and $40,000 on gauging and related quality control equipment. They would have spent much the same if they had developed any specialized line of fasteners. They would not have gone to another specialized line if the demand for metric had not been growing.

MacLean-Fogg spent the $200,000 over a short period. They decided to make a complete conversion rather than spend the same amount piecemeal over several years. They may have purchased $15,000 to $20,000 worth of tools they may never use because of the lack of standards in the automotive industry for fasteners. They currently make minor investments in metric--replacing worn-out tools and doing other maintenance. Initially they had problems mixing fasteners and contaminating equipment with the blue dye used to color code metric fasteners. MacLean-Fogg is now adept at changing from customary to metric production.

MacLean-Fogg made the investment on their own. Ford and their other customers did not pay the tooling costs. MacLean-Fogg wanted to develop its own line of metric fasteners. Some of the investment has been recouped as part of the piece costs customers pay for MacLean-Fogg nuts. As a result of the investment, MacLean-Fogg is one of the few approved suppliers of metric nuts in the auto industry.

Exhibit 25A

MACLEAN-FOGG'S PRODUCTS

M-F TWO-WAY LOCK NUT		All-metal type with lock in center of nut
M-F UNI-TORQUE LOCK NUT		All-metal type with lock at top of nut
M-F NYLON INSERT LOCK NUT		With locking nylon collar
M-F WHIZ-LOCK NUT		"Flange" and "Twin" free-spinning lock nuts
M-F WHIZ-LOCK SCREW		Hex and Flange types, free-spinning
M-F FLANGE NUT		Large and small flange, with or without lock
M-F FLANGE NYLON INSERT LOCK NUT		Flange nut with nylon locking collar
M-F PIERCE NUTS		Self-clinching nuts in coil strip form
M-F WELD NUT		Square or hex, long and short pilot
M-F CAP LOCK NUT		Open End and Closed End
M-F NO. 1 LOCK NUT		All-metal type to hold common nut in place
M-F SPEED LOCK NUT		Reversible hex or square type
M-F STANDARD NUTS		Slotted and castellated nuts, finished hex and thick nuts, heavy hex and square nuts

Parts and Service

Following the advice of Ford's Parts and Service Division, the team contacted five local dealers of Ford cars and trucks. Without exception, they reported the costs of metric conversion for the dealership as relatively minor. The only costs the dealership bears for metric are dual inventory costs for metric fasteners, special tools, and possibly some training costs.

When a new car is introduced the dealers must purchase the spare parts for service from Ford. Parts used in servicing Ford's new metric cars and trucks would be ordered whether they were metric or customary. The only additional costs for metric are in keeping a dual inventory of fasteners. The dealers do not consider this a substantial expense.

Dealers have also bought some special tooling for Ford's new metric vehicles. When a new vehicle is introduced, there are always a few special tools required to service the product. The number of special tools needed may have increased as a result of metric. If they have increased, the additional cost has been minor.

The primary cost of conversion at the dealer level has been borne by the mechanics. Dealers provide the specialized tools. Mechanics supply the standard tools. Metric tools are among the standard required tools. Dealers the team spoke with estimated the average costs for mechanics between $300 and $1,000. Ford offers training courses for its dealers' mechanics. The dealers pay to send their mechanics to these courses. Some dealers choose to pay the expense; others do not take advantage of the courses. Those who use the courses feel they have sent their people to more courses as a result of the metric.

All Ford vehicle shop manuals include an appendix on metrics that addresses metric fastener nomenclature and strength identification. Conversion charts give English/metric, decimal/metric, and torque equivalents.

The impact of metric on dealers of Ford vehicles may increase in the future. The metric vehicles have been in service for at most two years. Since people are not buying many new cars and are holding on to older cars, most of the dealers' service work remains in customary. They expect the amount of metric work to increase over the next five years.

Summary

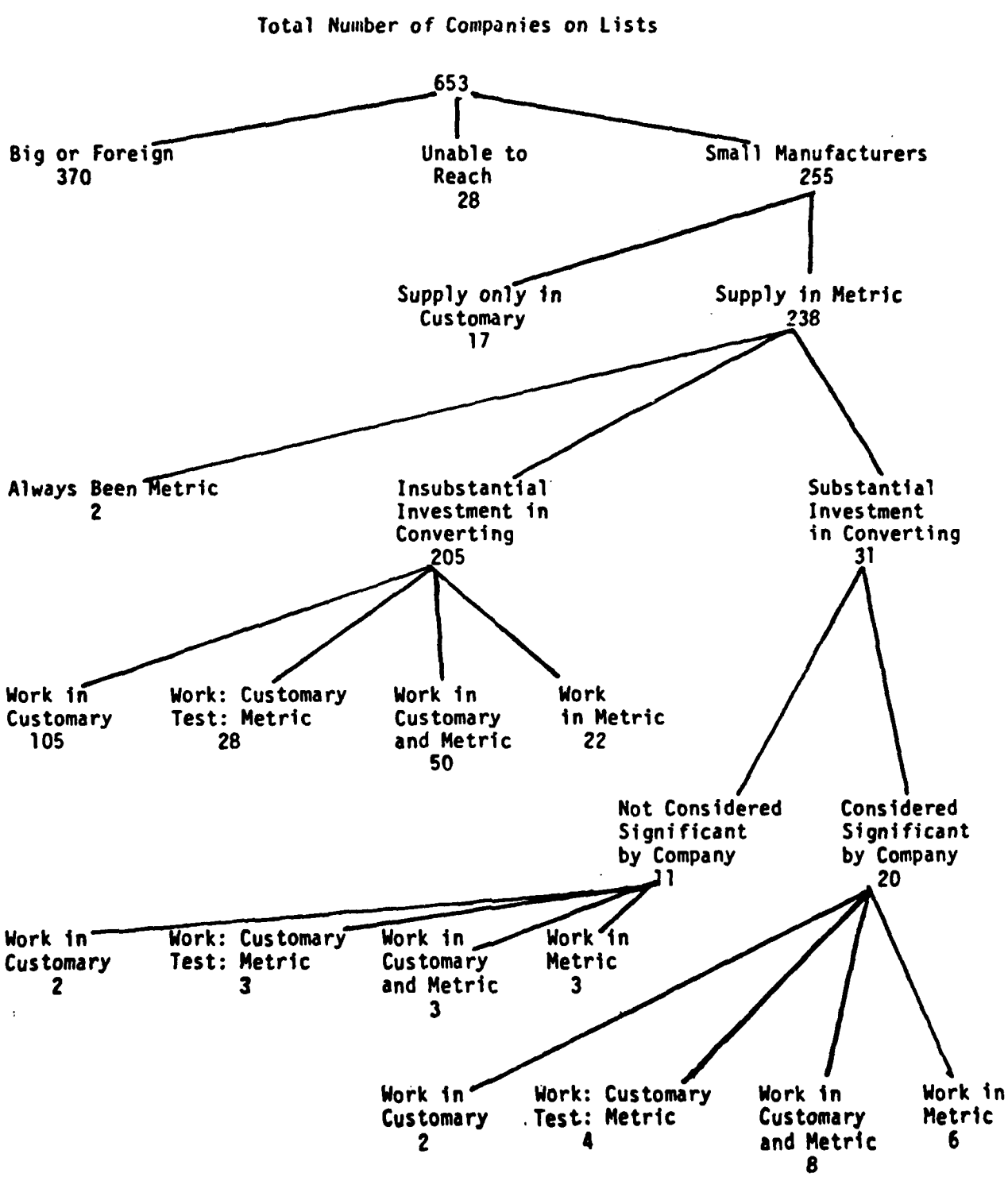
Ford's suppliers and customers easily accommodated to Ford's conversion. Suppliers see it as a routine part of doing business with Ford and the other automakers. Whether producing prototype parts, making production parts, or servicing cars and trucks, the companies report the same experience - no problems, no costs, no benefits.

Suppliers to Ford are producing metric with little investment. Exhibit 26 breaks down the responses of the 255 small manufacturers contacted. Most of the manufacturers (103) make insubstantial investments because they continue to work in customary dimensions. Few (6) have made what they consider to be a significant investment to be able to produce metric products using metric dimensions.

Suppliers have benefited from converting by keeping their business with existing customers. A few of the companies report getting more business. None of the companies, those making customary as well as those making metric products, reported losing business as a result of metric. In general, the experience of the suppliers confirms the Ford view of its effect on suppliers - suppliers and customers handle metric easily.

Exhibit 26

METRIC ACTIVITY IN FORD SUPPLIERS



REPORT TO THE U.S. METRIC BOARD

LARGE BUSINESS-SMALL BUSINESS INTERACTION ON METRIC CONVERSION

CASE STUDY

INGERSOLL-RAND COMPANY

--IMPCO DIVISION
Nashua, New Hampshire

--PORTABLE COMPRESSOR DIVISION
Mocksville, North Carolina

--POWER TOOL DIVISION ROANOKE FACILITY
Roanoke, Virginia

Henry H. Hitchcock
Marcy M. Canavan
Joseph F. Coates
M. Suzanne Nettles

PREFACE

Metric measurement is increasingly common in American life -- from missiles to soda bottles, from weather to track events, from machine tools to liquor bottles. This conversion to metric measurement has raised controversy in stores, homes, schools, legislatures, factories, and offices. Why do we have to go metric? Why are we the only ones not using the metric system? When will we completely convert? Does everything have to be changed -- even football fields?

Concern and controversy have been particularly strong regarding small businesses. Will conversion hurt or help small businesses? As part of its statutory mission the U.S. Metric Board has sponsored research projects looking at the implications of metric conversion for the nation's small businesses. This study involves detailed accounts of the conversion experiences of small manufacturers. It follows a more general survey of the metric activity and attitudes of small businesses in manufacturing, wholesale, retail, transportation, and construction.

In the first phase of this detailed look at small business experiences in converting to metric, the study team contacted 1161 companies trying to find small businesses making substantial investments in converting to metric. Although only seven substantial investors were found, an interesting portrait of the dynamics and pattern of conversion of small businesses emerged. Central to the portrait was the importance of large businesses to small business conversion to metric. Small businesses convert because their customers ask for metric products. The customers most frequently requesting metric products are large companies.

Observers have speculated, commented, or argued about the interaction of large and small businesses on metric production; little research has been done on the relationship. Case studies fill this need by looking at the costs, benefits, problems, and opportunities for small businesses in converting in response to large corporations' actions. They also reveal how small business supplier and customer considerations enter into large corporation decisions on metric production.

Do large companies use small companies to produce metric products? Who bears the costs of metric conversion to meet the large companies' needs? Do small businesses convert because of one or several large customers? Do small companies turn to the large companies for assistance in converting? Who benefits from metric conversion? Is anyone hurt by conversion? These are the types of questions addressed in these case study reports.

This report covers the conversion of three divisions of Ingersoll-Rand--the IMPCO Division in Nashua, New Hampshire; the Portable Compressor Division in Mocksville, North Carolina; and Roanoke Facility of the Power Tool Division, Roanoke, Virginia.

Ingersoll-Rand, its divisions, and its suppliers actively cooperated in the case study. At Ingersoll-Rand corporate offices, Jassie Master, Manager--Technical Operations, charged with coordinating company metric activities, organized and guided the study team in its visits with the three divisions.

AT IMPCO, Ralph Schult, Supervisor of Engineering Standards, organized the team's visit. Art Farrell, Manager of Engineering Services, was also most helpful. Other IMPCO staff members who spent time with the study team include: Thurston Robinson--Purchasing Manager; David Pacquin--Supervisor of Planning and Standards (manufacturing); Henry Caira--Manager, Quality Assurance; and Paul St. Louis--Manager, Customer Service.

At Portable Compressor, Barnes Daniels, metric coordinator, arranged the team visit and gave us valuable comments on the division's conversion. Sandra Albert, a Purchasing buyer, assisted the team in identifying and locating suppliers. Other staff members at Portable Compressor who contributed to the study include: Lewis Williams--Manager, Design Services; Lee Davis--Manager, Manufacturing Engineering; Fran Borden--General Foreman, Manufacturing; Ted Flatt--Manager, Quality Control; and John Cottle--Senior Buyer, Purchasing.

At Power Tool Division Harry Leidich--Manager, Engineering directed the team visit and assisted in the identification of suppliers. Other staff members of the Power Tool Division who assisted the team include: John Manning--Manager, Product Engineering; Les Jones--Staff Designer; Raymond Cooper--Manager, Industrial Engineering; William Pickering--Development Coordinator, Purchasing; John McManus--Manager, Purchasing; Wayne Flippen--Sub-Contract; and Charles Reese--General Foreman.

Many Ingersoll-Rand suppliers spent time with the study team discussing their experiences with metric. Without their cooperation the case study could not have been done.

At the U.S. Metric Board, Gene Visco, Ed McEvoy, and Stan Parent were attentive, interested, and involved patrons. Rhoda Baum was responsible for the production of the report; she was assisted by Bernice Mann and Barbara Bullard.

This report was prepared for the U.S. Metric Board under Contract Number AA-80-SAC-X8604. Any opinions, findings, conclusions, or recommendations expressed in the report are those of the authors and do not necessarily represent the views of the U.S. Metric Board or Ingersoll-Rand.

TABLE OF CONTENTS

EXHIBITS

EXHIBITS, continued

SUMMARY

General Finding

In 1975 Ingersoll-Rand Company decided to manufacture its new machines to metric dimensions where economically and technically practical. Implementation of this decision was left to the specific divisions of Ingersoll-Rand. The experiences of three divisions show metric fits comfortably into established relations with suppliers. Suppliers have accommodated the Ingersoll-Rand demand for metric with few problems, little cost, and few benefits. There are several reasons for the ready acceptance of metric:

- Ingersoll-Rand divisions are not major customers of metric products. Few suppliers do more than one fourth of their metric work for Ingersoll-Rand divisions.
- Ingersoll-Rand divisions have not pressed their suppliers to provide metric products. If the product is available in metric, they will use it. If the product is not available, the division will use a customary product. Divisions resist paying premiums for metric products.
- Ingersoll-Rand divisions take advantage of the metric capability spurred by large orders from companies such as IBM, General Electric, General Motors, Caterpillar, and others.
- Ingersoll-Rand divisions do not care if their products are produced using customary or metric dimensions as long as the quality is acceptable. Many suppliers of metric products choose to work in customary units to produce metric products.

The Case Study

The general findings above, and the detailed findings below, come from a study of Ingersoll-Rand Company's conversion to metric -- specifically the conversion of the IMPCO Division in Nashua, New Hampshire; the Portable Compressor Division in Mocksville, North Carolina; and the Power Tool Division's Roanoke Facility in Roanoke, Virginia. The case study looks at how small businesses respond to a large company's metric needs. Large corporations' demands often drive small business conversion to metric.

Previous research led to hypotheses about the interaction among large and small businesses on metric. The study team investigated these hypotheses through interviews with appropriate departments at IMPCO, Portable Compressor, and Power Tool Facility, and phone contacts with 42 IMPCO suppliers, 127 Portable Compressor suppliers, and 41 Power Tool Suppliers.

Detailed Findings

The detailed findings emerging from the contacts and interviews fall under five general headings:

The Ingersoll-Rand Approach

- Ingersoll-Rand divisions do not force their suppliers to convert to metric. If a part is not readily available in metric, they order it in customary. On custom designed parts, Portable Compressor provides suppliers with conversion tables if requested.
- Metric fits comfortably into the established ways Ingersoll-Rand divisions deal with their suppliers. The divisions encountered some confusion among suppliers when they first converted; these problems passed within the first year of conversion.
- Some errors were encountered in the initial stages when Portable Compressor's Manufacturing Department worked with drawings that had conversion tables added to them. This was the only metric related problem encountered.

Metric Suppliers

- Half of Portable Compressor's suppliers, 60% of IMPCO's suppliers, and 63% of Power Tool's suppliers make metric products for the divisions.
- Of those companies supplying only customary parts to IMPCO, Portable Compressor, and Power Tool, approximately 20% are supplying metric products to other companies.
- Half of the small companies supplying IMPCO with metric products have 115 employees or fewer; half of the Portable Compressor small metric suppliers have 58 or fewer employees. Of Power Tool's metric suppliers, half have 45 or fewer employees.
- Small metric suppliers to IMPCO, Portable Compressor, and Power Tool do little of their total production to metric dimensions. The average IMPCO supplier does 10% of its production to metric, while the average Portable Compressor metric supplier does 19% of its production to metric dimensions. For Power Tool suppliers, the average production to metric is 15%.

Ingersoll-Rand's Role

- IMPCO, Portable Compressor, and Power Tool account for little of their suppliers' metric work. Half of IMPCO's metric suppliers do 10% or less of their metric work for IMPCO; half of Portable Compressor's metric suppliers do 5% or less of their metric work for Mocksville; half of Power Tool's suppliers make less than 10% of their metric products for Roanoke.

- These metric suppliers work for several different industries including automotive, textile machinery, tobacco, shipbuilding, aircraft, trucks, office equipment, and electronics. A number of the small metric suppliers also work for foreign companies.

Investment in Conversion

- IMPCO, Portable Compressor, and Power Tool suppliers spent little to produce metric products. Half of IMPCO's metric suppliers and a third of Portable Compressor's suppliers spent nothing to make metric products. All of IMPCO's suppliers spent less than $5,000. Four of Portable Compressor's suppliers spent between $5,000 and $10,000 converting to metric. Four of every ten metric suppliers to Power Tool spent nothing to produce metric products. No suppliers spent more than $10,000.

- Many small suppliers continue to work in customary. Over half of IMPCO's suppliers, 42% of Portable Compressor's suppliers, and 48% of Power Tool's suppliers work only in customary to make metric products. Three percent of Portable Compressor's suppliers, 19% of IMPCO's suppliers, and 12% of Power Tool's suppliers work in metric to produce metric products.

- The small investments made by IMPCO, Portable Compressor, and Power Tool suppliers bought metric quality control equipment and metric capabilities for new and older machines.

- Companies servicing IMPCO, Portable Compressor, and Power Tool products have not made any investments or had any problems as a result of metric conversion.

Effects of Conversion

- IMPCO, Portable Compressor, and Power Tool have not dropped suppliers as a result of metric conversion. Divisions have added several distributors of metric hardware.

- The quality of IMPCO and Power Tool suppliers' products has not decreased because of metric conversion. At Portable Compressor there was an initial increase in rejection of supplier parts because of errors in conversion tables on Portable Compressor's drawings.

- Few small metric manufacturers report any problems as a result of metric production. A few cite the inconvenience and time involved in converting and difficulties getting metric supplies.

- Few suppliers see any benefits from converting to metric. A few mentioned new domestic customers, new foreign customers, or keeping existing customers. Two suppliers mentioned less competition on metric since some companies will not work on metric orders.

I. CASE INTRODUCTION

Introduction

Do large companies drive the metric conversion of small businesses? To investigate this question, the U.S. Metric Board sponsored several case studies of the interaction of large and small businesses on metric conversion. This case study involves Ingersoll-Rand Company -- a multi-national, diversified manufacturer of machinery and other products. The case study looks at the conversion experiences of three divisions within Ingersoll-Rand in terms of (a) the effects of conversion on the ways divisions work with suppliers, and (b) the effects of conversion on the suppliers. This section gives background on Ingersoll-Rand and its conversion to metric, how the case study was done, and what this case report contains.

Why Ingersoll-Rand?

Ingersoll-Rand is a major machinery manufacturer. Their products are used in oilfields, cars, factories, homes, streets, and underground, by many different industries -- automotive, chemical, oil, construction, mining, and others. No one market accounts for more than 30% of Ingersoll-Rand's sales -- which in 1981 were over $3.3 billion. Despite the downturn in the economy, 1981's sales surpassed sales of 1980. Ingersoll-Rand's growth is tied to diversity. In the early 1970's when construction and mining were growing, Ingersoll-Rand's sales grew as well. In the late 1970's as the construction and mining growth tapered off, the oil and chemical industry expanded. Now, Ingersoll-Rand's growth comes from the expansion of the energy industry, the retooling of the automotive industry, and a widespread move to improve the production facilities of American industry.

As an international company, 40% of Ingersoll-Rand's 1980 sales came from products for export. This was up from 37% in 1979. One-fifth of workers in its domestic plants owe their jobs to exports. Ingersoll-Rand sees developing countries as a major growth area for the future -- especially the major construction projects such as bridges, dams, roads, airports, and hydro-electric systems. In addition, the company has plants in 16 countries. Growth in the last few years includes Latin America and the Asia/Pacific region.

In 1975 Ingersoll-Rand corporate management decided to change from existing measuring system to the metric system and appointed a metric coordinator. The decision to convert was based on the premise that within 10-15 years a major portion of the U.S industry will have converted to the metric standards. However, the company's divisional differences were recognized because of differences in products and markets. The timing of conversion was and is allowed to vary from division to division and indeed in some instances from product to product within a division.

The corporate plan was to introduce metrication on a gradual basis with the objective of minimizing the costs involved. Exhibit 1 is the corporate standard on metrication policy. Each division was required to establish a Divisional Metric Coordinating Committee with members from major functional areas, including manufacturing, purchasing, quality control, and engineering. The divisions establish the best plan to suit their requirements and needs while working within the general guidelines of the corporate policy.

A Metric Engineering Data Manual (see Exhibit 1A) was issued by the corporate coordinator to define the company's metric plan and timetable, establish the method and procedure to follow, and assure a well-planned and orderly transition. The Manual also provides assistance in understanding the nature of the changeover and the potential benefits to be gained from the conversion. The corporate department also developed metric training guidelines for re-educating every employee to think metric. Three different types of instruction books were prepared for various levels of requirements. These were distributed during training sessions.

The number and diversity of suppliers, different rates of conversion determined by divisional product development programs, and the degree of international market involvement, and the different types of products produced by the different divisions make Ingersoll-Rand an appropriate choice for a case study.

Exhibit 1

Ingersoll-Rand Company

CORPORATE ENGINEERING STANDARDS

TITLE: METRICATION	NO: 6
	ISSUE: 1
	PAGE: 1 OF 4
PREPARED BY: J. Master APPROVED BY:	DATE: March 1977

TABLE OF CONTENTS

1. INTRODUCTION

The United States has committed itself to a voluntary program that will increase the use of the metric measuring system. Ingersoll-Rand has decided to change from the existing measuring system to the metric system in line with the major portion of the US industry.

This standard describes the nature of the changeover and the method of conversion.

2. OBJECTIVE

The purpose of this standard is to define the company's metric plans and timetable for metric conversion, to establish the method of conversion and to introduce the Metric Engineering Data Manual which contains full background data and details on all technical topics associated with conversion to the metric system.

3. NATURE OF THE CHANGEOVER

Metrication is the process of changing our existing measuring system to the internationally accepted metric-SI (Systeme International) system. This involves not only a new measurement system, but also includes changes in standards.

The objective of metrication in I-R is to make SI the predominant system of measurement throughout the company. Use of SI will provide a common international measurement language.

The change to SI will provide significant simplifications in measurements and calculations. It will afford the opportunity to revise standards and procedures and to establish more rational techniques for design, size selection, and inventory control.

Manufacturing equipment, machine tools and gauges will be progressively changed over. As a general rule, all machine tools can be utilized to produce components to either inch or metric dimensions, provided the machines and the operators have the necessary measuring equipment.

4. METHOD AND TIMETABLE – CORPORATE PLAN FOR METRICATION

It is accepted that within the next 10 - 15 years a major portion of U.S. industry will have converted to metric standards. Within I-R the timing for conversion to metrics will vary from division to division depending on the markets served and on the availability of metric components used in each division's products.

Metrication of Torrington, Schlage and Proto products will be dictated almost solely by customer requirements. On the other hand, in other divisions (Rock Drill, APCD, Centac, Small Compressor, Terry, Portable and Pulp Machinery) metrication of selected products is already in process. Recognizing the present need for a corporate plan to insure an orderly transition to metric at minimum cost, a corporate metrication policy was established. The policy includes the flexibility to accommodate the different needs of the divisions, and states that:

> Ingersoll-Rand will change from the existing English measuring system to the metric system throughout all divisional operations of the company. The metric system and the standards shall be in accordance with those established by the International Standards Organization.
>
> The plan is to introduce metrication on a gradual basis, with the objective of minimizing the costs involved. 1985 has been set as the target date for complete conversion to the metric system.

A. Divisional Metric Committee

Each division will establish a Divisional Metric Coordinating Committee with members from major functional areas, including Manufacturing, Purchasing, Quality Control and Engineering, to work with the Manager of Metrication (Corporate) and establish specific conversion plans, product by product, for the division.

B. Cost

Each Divisional Metric Coordinating Committee must estimate the cost of conversion corresponding to the established divisional metrication plan. This estimate will be submitted to the Group Vice President for approval by the Executive Office prior to implementation. As part of the 1978 capital plan (and for each subsequent year) the plant and division must identify the capital cost on metric conversion. This would be submitted as part of the regular capital program to the Director of Capital Planning.

C. New Products

Effective January 1, 1977, all completely new products, both in new areas and extensions of the current line, should be designed in hard metric.

Design of products which are only partially new, but using existing components, should also be in metric units. As far as possible the part of the product that is new will be designed in hard metric, with the remainder soft converted.

Deviations are permitted when compelling market or economic conditions, or lack of manufacturing capabilities dictate delay. Such deviations must be recommended by the Divisional Metric Committee and the Manager of Metrication (Corporate), and approved by the divisional General Manager and the Group Executive.

D. Existing Products

Conversion of existing products with an expected life beyond 1985, will begin no later than January, 1980. The conversion from the English to the metric system should be a soft conversion except for the hardware items. Products expected to be obsoleted by 1985 will not be converted.

E. Drawings

As soon as possible, but not later than January , 1978, all design and drawing work in the Engineering Departments will be in soft or hard metric.

F. Machine Tools

Continue with the existing program for the purchase of machine tools capable of both English and metric work. Convert machines to dual language as needed to produce metric parts. Conversion should be completed no later than 1985.

5. SCOPE OF THE METRIC ENGINEERING DATA MANUAL (MEDM)

The I-R Metric Engineering Data Manual establishes the method and the procedure to be followed when converting to the metric system, and assures a well-planned and orderly transition.

The purpose of the Manual is to assist in understanding the nature of the changeover and the potential benefits to be gained from the conversion.

The Manual describes and lists preferred metric measuring units and practices and includes information for the preparation of metric drawings. It identifies and describes the Corporate, National, and International Standards to be used in designing metric products and components. The Manual also provides useful tables of preferred sizes of metric material and purchased components.

6. USE OF THE MEDM

The MEDM applies to all I-R operations worldwide: to operating divisions, international locations, wholly owned companies, affiliates and autonomous companies.

Since many of the International locations are familiar with the metric system, and in some instances are using some form of metric units, the implementation for them shall be:

- Prepare a metric conversion program in line with product metrication of U.S. operating divisions.
- Convert machines and equipment necessary to meet the domestic conversion programs.
- Where alternate SI units have been established in common usage, continue the use of these units.
- National Standards or local availability may dictate the use of materials and components not recognized as I-R Standards. At their option, and after due consideration is given to interchangeability, the location may continue to use these materials and components. However, at the first opportunity, efforts must be made to bring all practices in line with International and I-R Standards.

7. FORMAT AND DISTRIBUTION

The hard-copy version of the MEDM is issued as a separate, self-contained, three-ring binder marked on the exteriors with the legend "Metric Engineering Data Manual".

One hard-copy of the MEDM accompanied by the appropriate quantities of 24X-98 fiche cards, are provided to all I-R divisions/facilities, affiliates, and autonomous companies and international operations. Distribution is based on mailing location, and the number of copies at a particular location is determined by the cognizant local management.

In order to simplify the distribution and additions, the manager of each mailing location appoints one individual as custodian, who then has the responsibility for all the manuals at that location. The custodian maintains the internal distribution list for the location and acts as liaison with the Manager of Metrication (Corporate).

8. RESPONSIBILITY

Responsibility for the issuance and distribution of the MEDM and for issuance of additional material to the MEDM rests with Manager of Metrication, Corporate Engineering, in Princeton, N.J.

9. REVISIONS AND ADDITIONS TO MEDM

Some parts of the Manual such as the interim recommended standards and component availability may be revised as National and International differences are resolved. Additions will be made to the Manual as new metric standards are developed.

Anyone requiring the latest status on standards and availability should direct their inquiries to the Manager of Metrication (Corporate).

Exhibit 1A

INGERSOLL-RAND METRIC ENGINEERING DATA MANUAL

TABLE OF CONTENTS

Ingersoll-Rand®

METRIC ENGINEERING DATA MANUAL

Ingersoll-Rand Company
Corporate Engineering Department
Box 301
Princeton, New Jersey 08540

March 1977

Exhibit 1A (continued)

Ingersoll-Rand Company

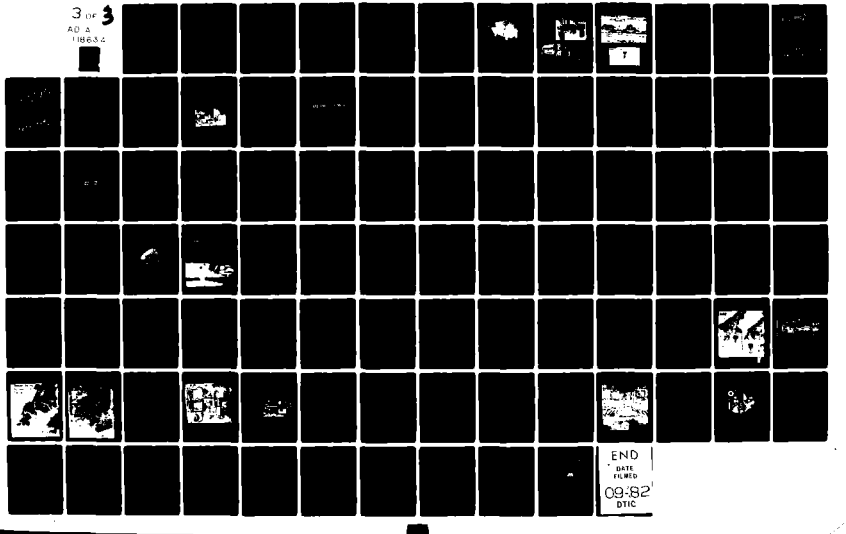
METRIC ENGINEERING DATA MANUAL

INDEX TO SECTIONS

Section

AD-A118 634 COATES (J F) INC WASHINGTON DC F/G 13/8
THE CONSEQUENCES OF METRIC PRODUCTION FOR SMALL MANUFACTURERS, --ETC(U)
FEB 82 H M HITCHCOCK, J F COATES, M M CANAVAN AA-80-SAC-X8604
UNCLASSIFIED NL

3 OF 3
AD A
118634



END
DATE FILMED
09-82
DTIC

The Focus of the Case Study within Ingersoll-Rand

To take the most advantage of Ingersoll-Rand's diversity, the team decided (on the advice of the Ingersoll-Rand metric coordinator) to look into three divisions. These divisions are at different stages of conversion and under different market forces.

- IMPCO - a builder of custom heavy machinery (such as centrifuges and flotation separators) in Nashua, New Hampshire that has been operating with metric design for several years.
- Portable Compressor - a manufacturer of portable air compressors. A large part of their product is made up of commercially available parts and equipment.
- Power Tool Division's Roanoke Facility - a producer of air starter motors, hoists, and winches. Some of their products are in metric; others remain in customary units.

How the Case Study was Done

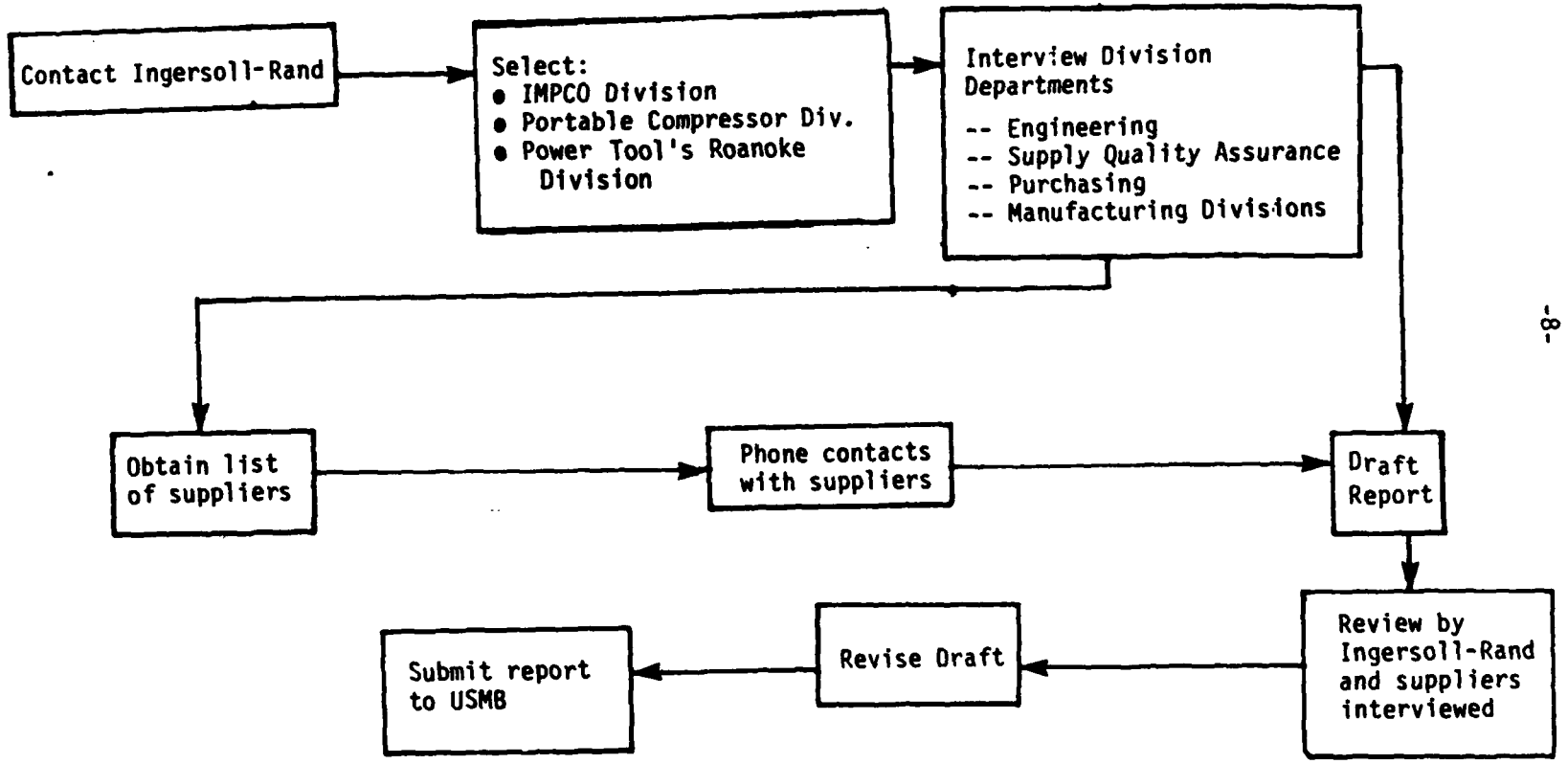
The Ingersoll-Rand case study is three case studies in one. While different in content, each division case study used the general plan shown in Exhibit 2. After securing the cooperation of Ingersoll-Rand corporate management, the team sought the cooperation of the specific divisions suggested by the Ingersoll-Rand metric coordinator. With this cooperation, the team visited the divisions and interviewed the appropriate departments:

IMPCO	Portable Compressor	Power Tool Roanoke Facility
Engineering Services	Engineering, Design Services	Engineering
Engineering Standards	Manufacturing Engineering	Industrial Engineering
Manufacturing	Manufacturing	Product Engineering
Purchasing	Purchasing	Purchasing
Quality Assurance	Quality Control	Sub-Contract

Each supplied the team with the names of firms supplying products. The lists contained the names of those suppliers most likely to be working in metric. The team asked for the names of as many small manufacturers as practical in order to insure the most complete coverage of the effects of Ingersoll-Rand's conversion. The IMPCO division list had 106 companies; of these, 42 were small manufacturers. The others were large companies or distributors. The team was unable to contact 4 of the companies on the IMPCO list. The Portable Compressor list had 265 companies, of which 127 were small manufacturers. The Power Tool Facility gave the team the names of 69 companies; 41 were small manufacturers.

Exhibit 2

INGERSOLL-RAND CASE STUDY FLOW



Divisions are indifferent to the size of a company when they place an order for metric and other types of products. They are looking for the best quality product at the lowest cost, with the best service, and delivered at the right time.

The team called the small manufacturers and asked if they produced metric products for the Ingersoll-Rand division that gave the team their name. If they were producing metric products, the team asked about the costs, benefits, problems, and opportunities for small businesses converting to metric. In these calls, the team looked for small manufacturers making substantial investments in converting to metric -- substantial by their own estimate as well as over $10,000.

The search calls did not uncover any companies making substantial investments in converting to metric. As a result, follow-up site visits were not required. A draft report was developed on the basis of the interviews with the Ingersoll-Rand division staff and the calls to the suppliers. This draft was circulated and reviewed by the divisions and revised.

What Follows

The next three sections cover the experiences of each division with suppliers of metric products. Each section has:

- summary
- background
- effects of conversion on relations with suppliers
- effects of conversion on suppliers

The overall findings from the three case studies were summarized in the previous section.

IIA. IMPCO SUMMARY

General Finding

Suppliers to Ingersoll-Rand's IMPCO division have responded to metric orders straightforwardly and without hardship. Most suppliers convert IMPCO's metric orders to customary units for production. None of the suppliers has spent over $5,000 converting to metric; few of the suppliers receive more than 10% of their orders in metric dimensions. IMPCO's orders are small. Thus, their business has not forced any companies to make significant investments in converting to metric. While IMPCO has not dropped suppliers as a result of metric, they have added a few distributors of metric hardware. IMPCO has followed a policy of converting only where parts are readily available in metric; as a result, their conversion has not created any effects on its suppliers.

The Case Study

The general finding above and the detailed findings below come from a case study of IMPCO's conversion to metric. The case study looks into how small businesses respond to large corporations' need for metric. Large customers' demands often drive small business conversion. Previous research led to hypotheses about the interaction among large and small businesses on metric. The study team investigated these hypotheses through interviews with the appropriate IMPCO departments and contacts with 42 small manufacturers.

Detailed Findings

The detailed findings are:

- Many small manufacturers working for IMPCO produce metric products. Of the 42 contacted, 60% produce metric products for IMPCO. Another 21% produce metric products for other customers but not for IMPCO. These metric manufacturers make castings, forgings, springs, and machined parts.

- Half of the small metric manufacturers supplying IMPCO have 115 employees or fewer; the average has 140 employees.
- IMPCO's small metric suppliers receive only about 10% of their orders in metric dimensions. Half receive less than 5% metric orders.
- IMPCO's orders are small; therefore, IMPCO is not a major factor in forcing its suppliers to invest in metric. Half of IMPCO's metric suppliers do less than 10% of their metric work for IMPCO. IMPCO accounts for 90% or more of 4 firms' metric production. Three of these companies devoted 2% or less of their total production to metric.
- IMPCO suppliers invest very little to produce metric products. Of the 25 metric suppliers, half said they had spent nothing. The other half spent less than $5,000 on tooling and quality control equipment.
- More than half (14) of IMPCO's 25 metric suppliers make metric products using customary dimensions. The others work in metric (5), in customary and metric (4), or in customary and inspect in metric (2) to produce metric products.
- Few suppliers report problems or benefits from conversion. Three companies mentioned problems with getting metric supplies; one company said they had expanded their foreign business as a result of metric.
- IMPCO converted its production machinery using its regular suppliers of machinery, tools, and gauges. An employee tool buying plan helped spread metric through the IMPCO plant.
- Metric conversion fit comfortably into the ways IMPCO deals with its suppliers. No suppliers were dropped as a result of metric. Several metric hardware distributors were added to the IMPCO suppliers as a result of conversion.

IIB. IMPCO BACKGROUND

Ingersoll-Rand, IMPCO

IMPCO is a division of the Industrial Process Machinery Group and has been a part of Ingersoll-Rand for seventeen years. IMPCO, located in Nashua, New Hampshire, employs more than 1,000 people and occupies a floor area of 55,000 square meters (about 590,000 sq. ft.).

IMPCO's traditional stronghold has been in the pulp and paper industry, primarily in the production of wood pulp. The division has been diversifying into liquid/solid separation equipment used in industries such as tobacco, mining, and food processing.

Typical IMPCO product lines include: stock preparation machines, mixers, pumps, separators, vacuum and disc filters, centrifuges and presses. Exhibit 3 shows some of the products. While IMPCO has standard product lines, many machines are engineered and built to meet customer specifications. Exhibit 4 shows the IMPCO production plant and the manufacturing facilities.

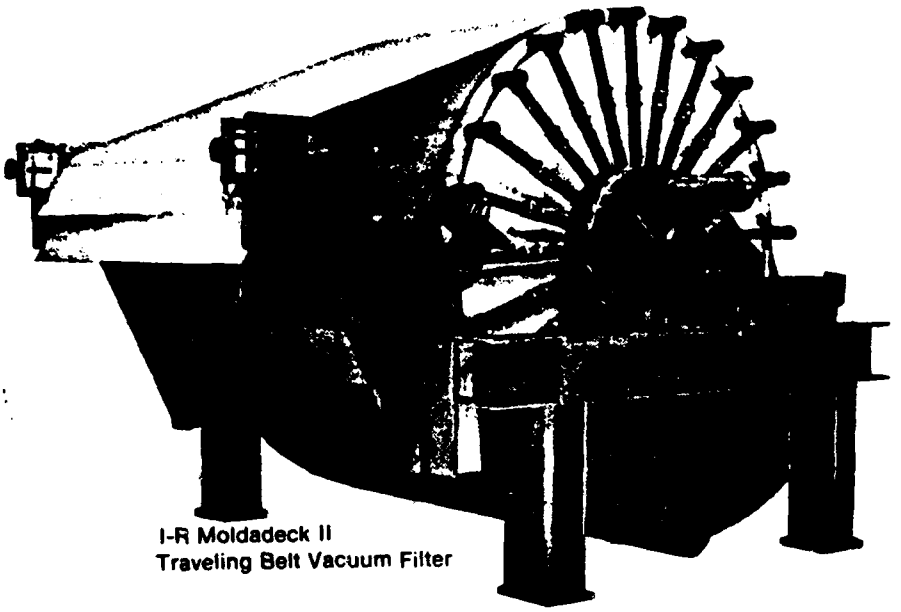
IMPCO's Metric Decision

IMPCO decided to do as much as feasible to follow the Ingersoll-Rand directive to convert to metric. IMPCO acquired a license for the United States' rights to manufacture three different machines from three different metric countries at roughly the same time I-R decided to metricate.

Exhibit 3

SOME IMPCO PRODUCTS

Vacuum Filter



I-R Moldadeck II
Traveling Belt Vacuum Filter

Air Flotation Separator

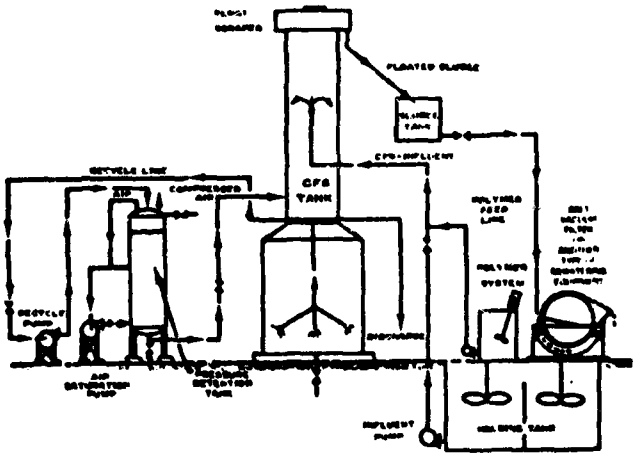
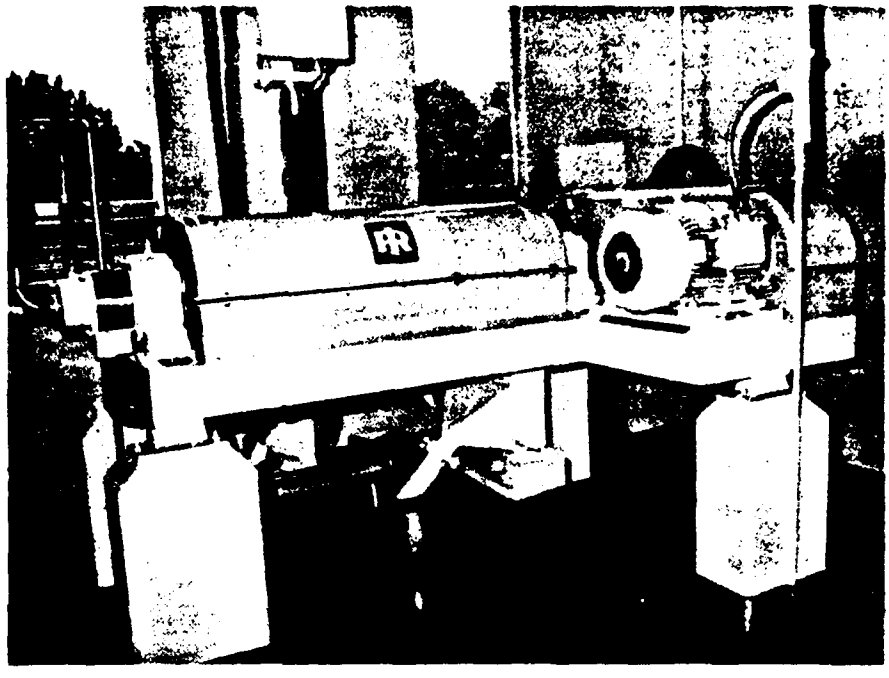


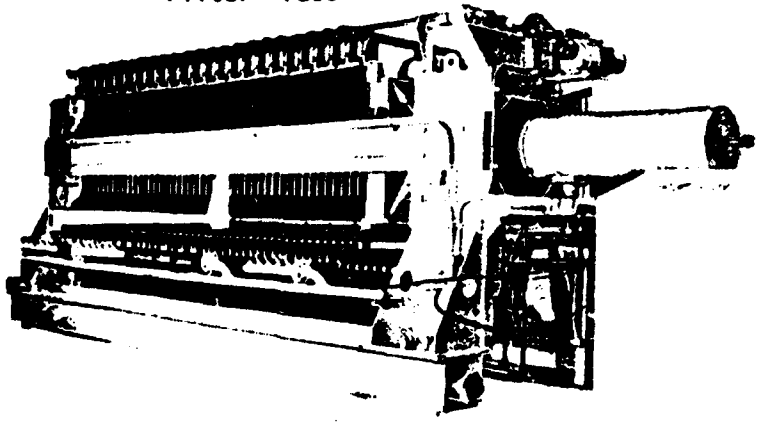
Exhibit 3 (continued)

SOME IMPCO PRODUCTS

Centrifuge



Filter Press



Twin Roll Press

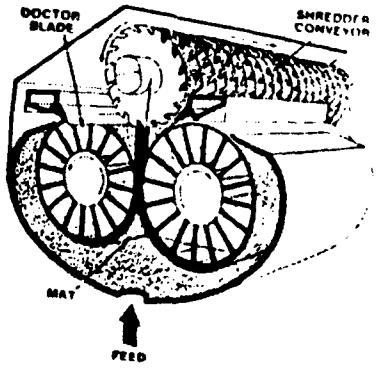
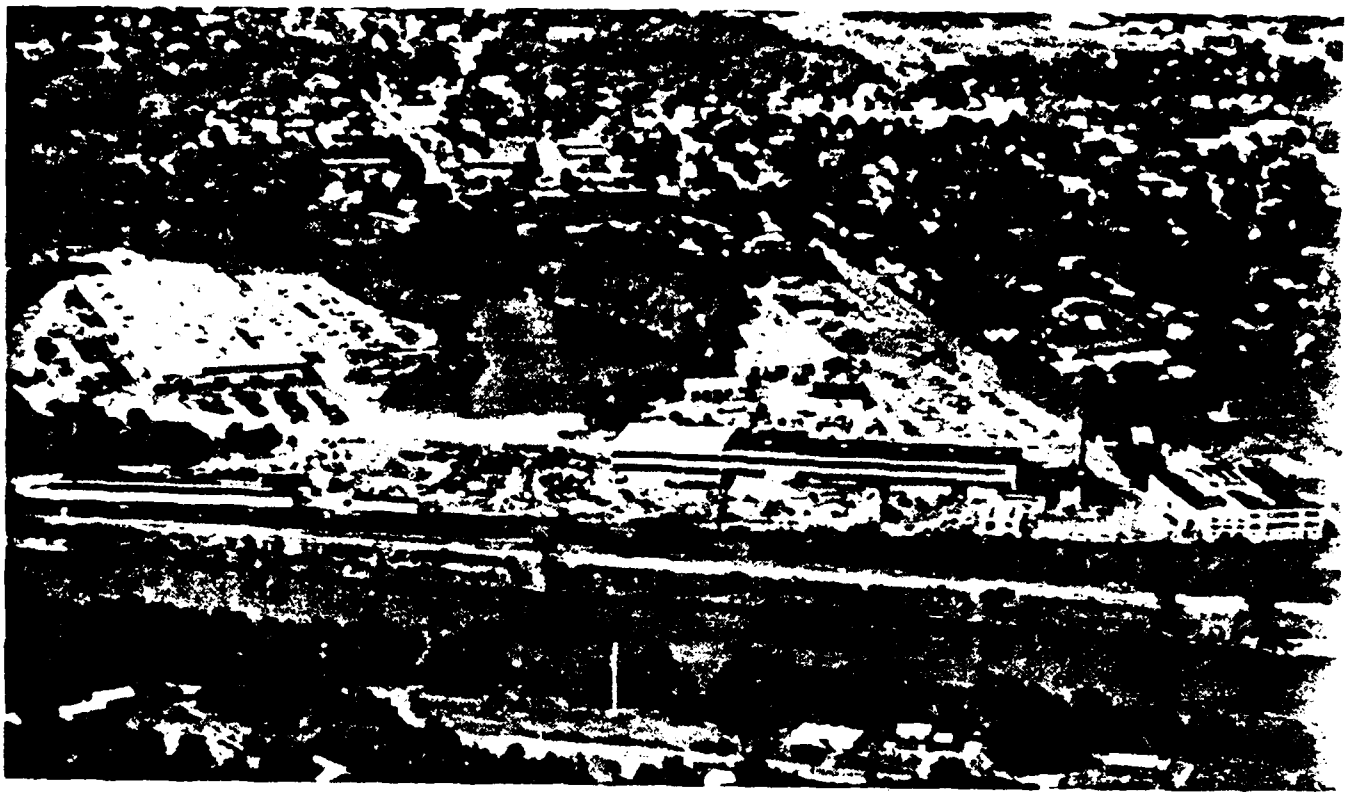


Exhibit 4

IMPCO MANUFACTURING PLANT



IMPCO's management planned its metric conversion. First, they established a metric committee, headed by Henry Caira of the Quality Control Department. In making its conversion, IMPCO relied on its own resources and the assistance of the Ingersoll-Rand metric coordinator. Corporate funds for conversion were not available.

The metric committee developed a training program for IMPCO employees. All IMPCO employees were instructed, in groups of twenty, about the metric system. Exhibit 5 shows the mobile metric training center developed by IMPCO. The trainers explained, showed films, and distributed metric manuals. Each trainee was given a 600mm ruler to make him familiar with the metric system. All manufacturing personnel received more detailed training and a 5 meter measuring tape. The machinists, fabricators, and quality control personnel got especially detailed training, tailored to their needs.

IMPCO follows up this training, keeping corporate personnel informed on metric developments. They purchase all applicable ISO standards as they are released send for all applicable catalogs, acquire all available fastener standar s, and circulate American National Metric Council reports throughout the plant.

The committee laid out long-range metrication plans calling for the phasing in of metric where applicable (see Exhibit 6). The committee endorsed the corporate management commitment to conversion with a metric conversion plan involving the least disruption and lowest cost. All new machines including licensed products are produced to metric dimensions.

Since the paper and pulp industry is not likely to convert in the near future, there is a limit to how far the IMPCO metrication plans can go. IMPCO machines must work with customary machinery manufactured by other companies. Metals also limit IMPCO's conversion; they continue to purchase bar, rod, and sheet metals in customary units. Metric-sized materials, especially in the high alloy steels, are available only at a premium.

An example of the extent of IMPCO's conversion is its metric twin roll press. It has some internal parts designed and produced in customary because metric-sized parts were not available. There was also a problem of interchangeability with existing twin roll presses.

Exhibit 5

IMPCO'S MOBILE METRIC DISPLAY

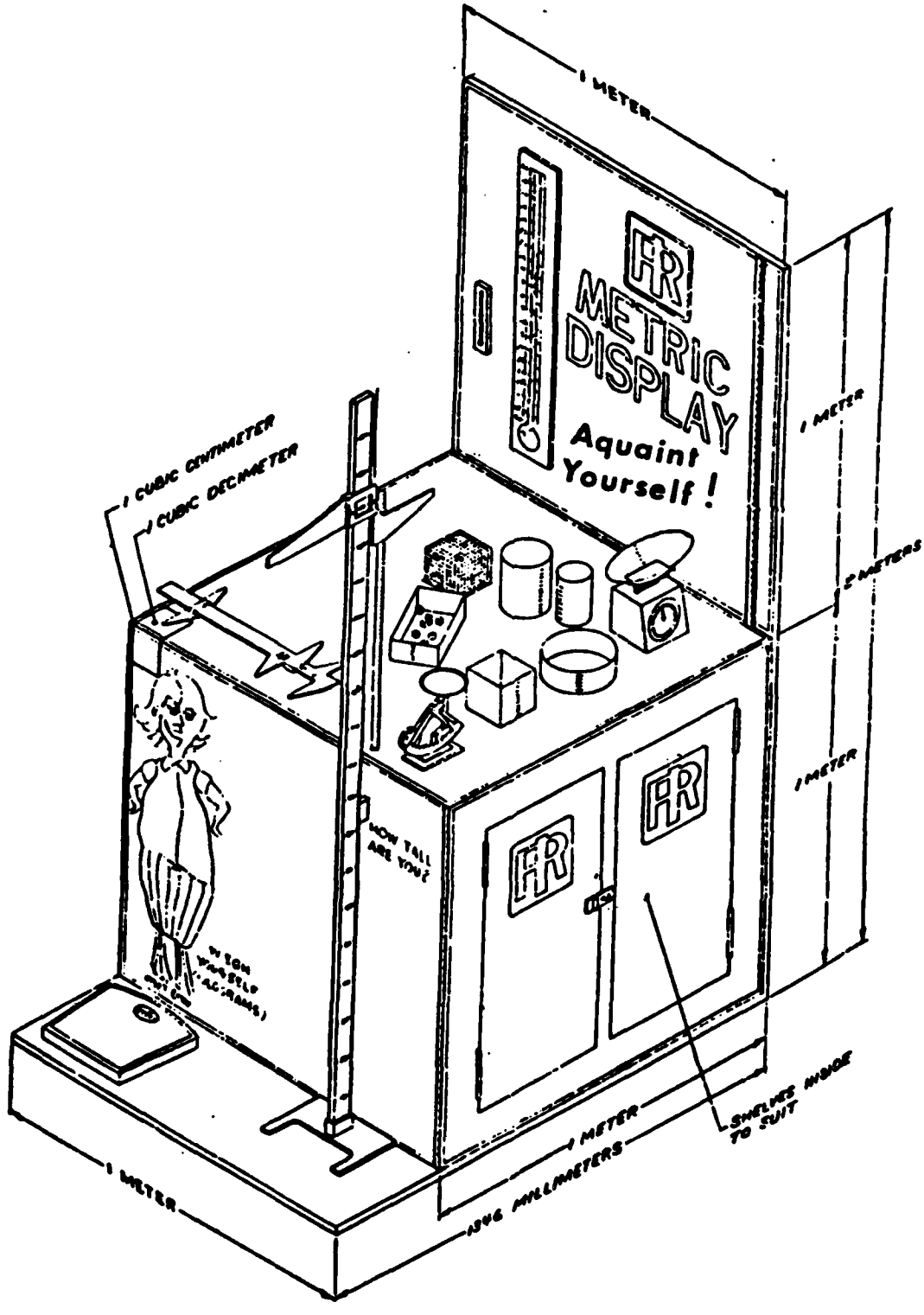
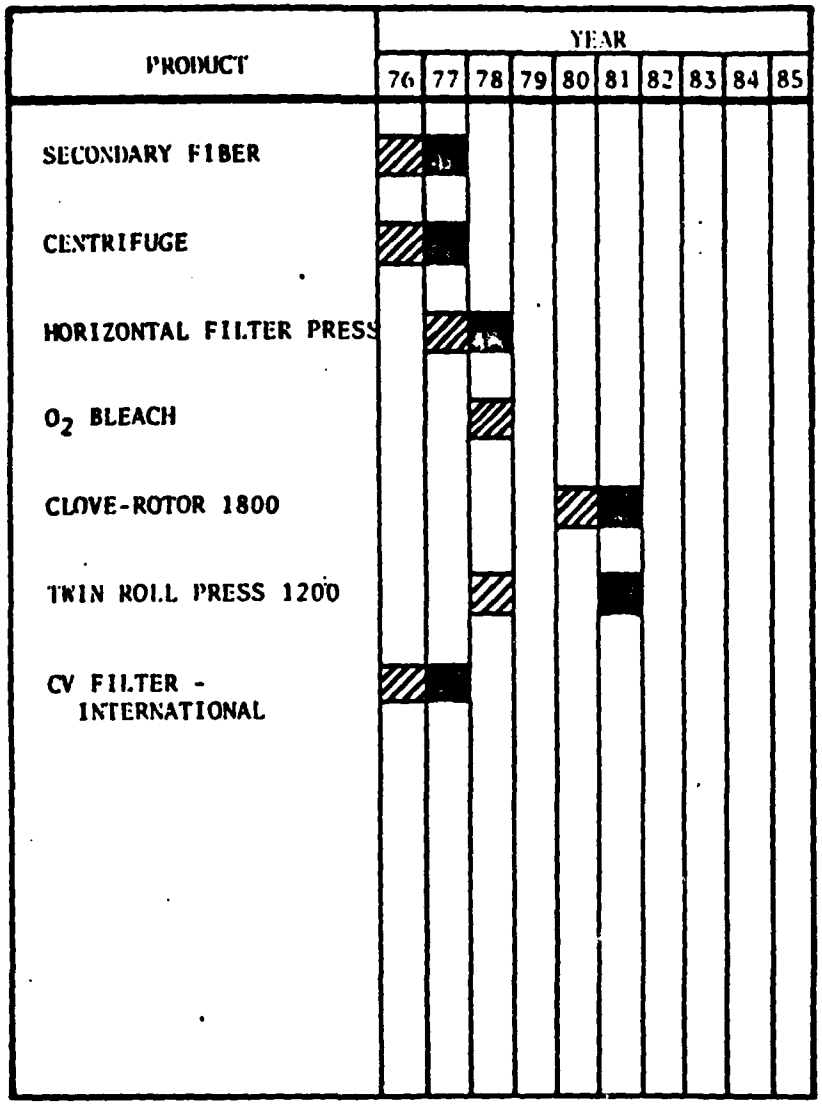
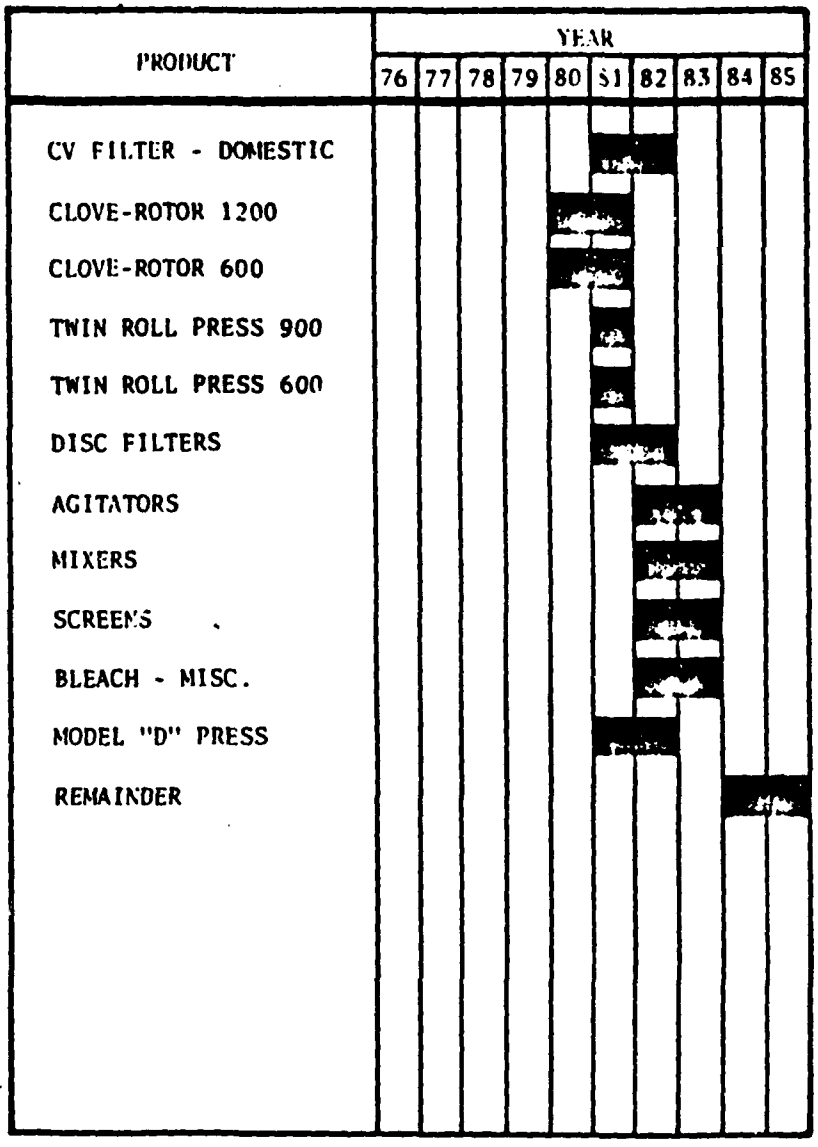


Exhibit 6

METRIC CONVERSION SCHEDULE



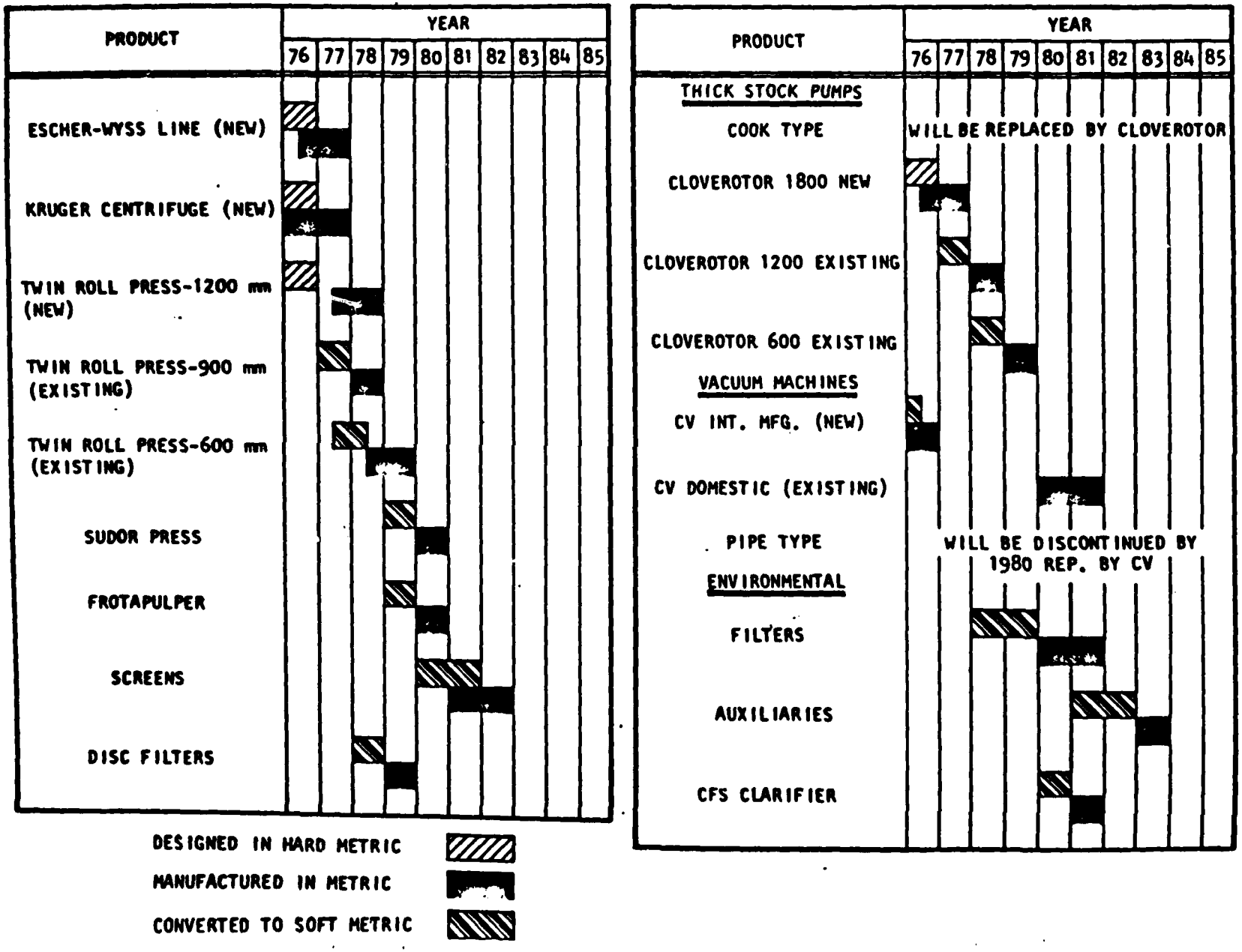


DESIGNED IN HARD METRIC UNITS

MANUFACTURED IN HARD METRIC UNITS

Exhibit 6 (continued)

METRICATION CONVERSION



Summary

IMPCO builds custom heavy machinery for indust . Where feasible, they have followed the Ingersoll-Rand corporate directive to convert new products to metric. They continue to do a large part of their work in customary units; however, metric is increasing its share. The following section describes how the shift to metric production has affected IMPCO's relations with its suppliers.

IIC. METRIC CONVERSION AND IMPCO'S RELATIONS WITH SUPPLIERS

Introduction

This case study of small business-large business interaction follows two paths -- the effects of conversion on small business suppliers and customers and the effects of metric conversion on the way the large company relates to its suppliers. Relations with suppliers refer to:

- Involvement of suppliers in design decisions
- Effect on design of customer and service organization considerations
- Effect on design and production of supplier capabilities
- Interaction and the relative importance of different departments dealing with small suppliers
- Primary considerations for each department in its relations with suppliers

To find how metric conversion affected the way IMPCO deals with its suppliers, the team first developed an overview of the way a product normally is designed, produced, and serviced. With that background, the team looked for changes resulting from conversion.

Metric fits comfortably into the ways IMPCO deals with its suppliers. IMPCO did not anticipate problems nor did they encounter any. The rest of this section elaborates this central theme through a description of the way IMPCO produces a product. The section follows conversion in four areas -- prototypes, production parts, production machinery, and service of IMPCO products.

Prototypes

IMPCO does extensive laboratory testing of new design concepts. Pilot size equipment is built and operated under conditions that duplicate feed stock, loading, speed, and temperatures anticipated for which the equipment is designed.

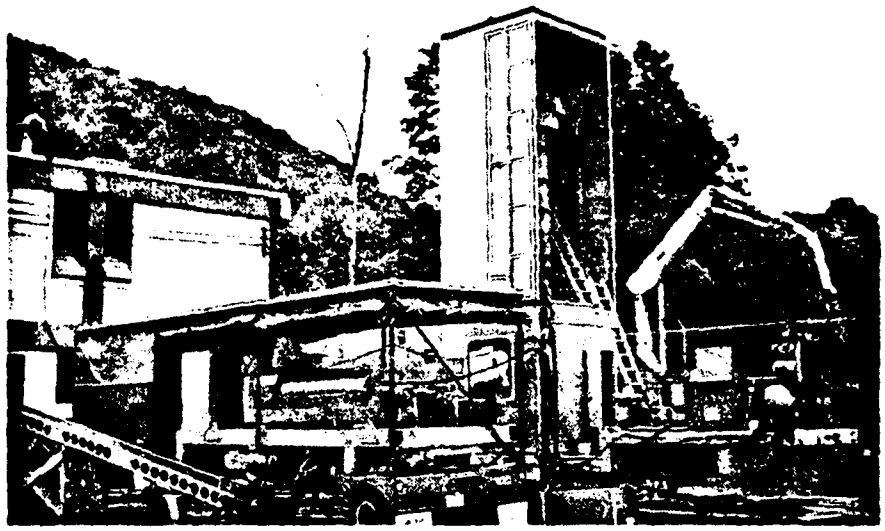
IMPCO has demonstration units mounted on flat-bed trailers that are fully equipped to run full-scale demonstrations at customer's location for some of its products (see Exhibit 7).

Exhibit 7

IMPCO PRODUCT DEMONSTRATIONS

FULL-SCALE DEMONSTRATIONS AT YOUR PLANT

No need to guess any longer about how well I-R liquid/separation equipment will work on your feed product. Full-scale, on-site demonstrations of our CFS countercurrent flotation separator, Kruger centrifuge, Vari-Nip press and Lasta press are available. This equipment is mounted on enclosed flat-bed trailors and driven to your facility.



In designing new products, Engineering consults with Purchasing or uses catalogs to check the availability of parts. Engineering designs in metric as far as practical. Quite a few of the engineers work solely in metric and have become accustomed to thinking in metric. Standard procedures for working with metric such as the proper rounding procedures have been developed and used. Some parts remain in customary; drawings are clearly labeled to prevent confusion in purchasing or manufacturing (see Exhibit 8). Computer design equipment has improved design capabilities, including metric design.

Production Parts

Most of IMPCO's suppliers make parts for the machines IMPCO produces. These parts range from a lock nut to a large metal casting. Engineering designs or specifies the part needed. Purchasing orders the products from the suppliers. Several features of IMPCO's purchasing of production parts deserve note:

- Orders are small because most of their work is custom.
- Many IMPCO products require special materials because of the corrosive and generally harsh environments in which they are used. This makes purchasing more difficult.
- Many of IMPCO's orders are for large castings. Dealing with local firms saves transportation costs.

Metric has not affected IMPCO's relations with its production parts suppliers. Purchasing does not care how products are made -- as long as they meet specifications. The following reviews the experience with metric in the three major types of products IMPCO buys:

- Standard Purchase Parts, which IMPCO can get off the shelf, such as common sizes of bolts.
- Special Purchase Parts, such as bolts made from special metal alloys.
- Internal Design Parts, such as a casting designed by IMPCO, intended only for IMPCO's use.

Exhibit 8

METRIC LABELS FOR IMPCO DRAWINGS

ALL METRIC DRAWINGS ARE IDENTIFIED WITH A LARGE DECAL THUS:

METRIC DWG.

DRAWING NUMBERING SYSTEMS FOR INCH AND METRIC DRAWINGS:

INCH DRAWING - D08-XXXX

METRIC DRAWING - 08D-XXXX

Standard Purchase Parts

IMPCO purchases these parts from distributors, not from manufacturers. At first, most metric standard purchase parts were imported from Europe. They were difficult to get in the U.S. and cost more than customary purchased parts. Since then, U.S. manufacturers have been producing metric hardware. Standard metric purchase parts are now easy to find. The initial difficulty in locating metric parts lasted about a year. IMPCO is not sure whether they now pay a premium for metric parts. If there is a premium, it is small.

Special Purchase Parts

Special Purchase Parts are modified versions of standard purchase parts. They cannot be ordered "off the shelf." But they are not so special that companies other than IMPCO could not use them.

Hardware is the most common type of special purchase part IMPCO has. A lot of IMPCO's hardware is custom ordered. Many of the special purchase parts that IMPCO buys are items designed by another firm, like electrical motors, over which IMPCO has little control. They might specify, for instance, that the motor be equipped with a special mount, but the motor itself is not designed by IMPCO.

At first, IMPCO may have paid a premium for metric special purchase parts. They did have problems getting metric parts, such as special alloy metric bolts. They ordered one grade and got a different grade as a result of confusion over specifications. IMPCO does not have any current problems with metric special purchase part suppliers.

Internal Design Parts

Internal design parts are designed by IMPCO engineers and have no application outside IMPCO. Suppliers make some of these items to IMPCO specifications; IMPCO may supply molds or patterns for some of these parts. With most, IMPCO supplies only a drawing. When patterns or drawings are supplied, they remain IMPCO's property. In many cases, IMPCO pays for the tooling or patterns used to make its internal design parts. IMPCO owns these tools and patterns.

Internal design parts are most likely to encounter problems with conversion. The first year of the conversion saw some problems as a result of conversion. Rejection rates were somewhat higher; several suppliers requested inch equivalents from IMPCO.

One supplier sent in three large metric parts that were not toleranced properly. Like most IMPCO suppliers, this supplier converted the metric drawings to customary. He made an error in converting. After this error, Quality Control established computer generated conversion tables for conversion and supplied these to vendors for six months (see Exhibit 9).

This practice was stopped after six months because it made IMPCO responsible for any errors of conversion. As long as the onus of conversion is placed on the vendor, IMPCO can reject any part which does not meet specifications.

For the first year of conversion the rejection rate on suppliers parts was higher on metric parts than it was on customary parts. After the first year, rejection rates returned to normal. The rejection rate on metric parts may be even lower now than for conventional parts; vendors may be more cautious when converting specifications than they would be in just following customary specifications.

In general, Purchasing has had few problems with metric production. After some initial confusion, metric became a routine aspect of doing business with IMPCO.

Production Equipment

As a custom shop, IMPCO has over 50 manufacturing machines -- turret lathes, grinding machines, lathes, drill presses, and others. The average machine will last 30 years. IMPCO has recently invested a substantial amount to upgrade its capital equipment. IMPCO spends in excess of $100,000 annually on disposable tooling, such as drills and cutting tools, or gauges, such as micrometers, calipers, and height gauges.

Ingersoll-Rand

Exhibit 9

IMPCO CONVERSION TABLE

DWG. TITLE PIPE-
COMPRESSED AIR
1500 ISD LASTA FILTER PRESS

Ingersoll-Rand
150 Burke St Nashua NH 03060
IMPCO

DWG. NO. CT-84M-0044
REV. A

DATE 3-20-79 SECTION PULP DIVISION DISTRIBUTE ☒ DON'T DISTRIBUTE ☐ SHEET NO. 1 of 1

NOTE: Ø EQUALS NUMERIC ZERO

DWG. NO.: 84M-ØØ44 DASH NO.: ( )

CONVERSION TABLE

MM	FT	INCH
24		15/16
26		1-1/32
28		1-3/32
32		1-1/4
102		4-1/32
104		4-3/32
137		5-13/32
139		5-15/32
409		16-3/32
413		16-1/4

REVISIONS TO CONVERSION TABLES

MM	FT	INCH

The IMPCO metric committee estimated an investment of $150,000 in converting the plant to metric. Exhibit 10 lists the different gauges, tools, and other products purchased for the different functional locations throughout the plant such as: tool cribs, lathes, weld shop, and grinders. The exhibit also shows the costs at the time of the estimate -- 1975. According to IMPCO personnel, the estimate was quite close to what was spent.

Two points about this investment deserve note. First, the digital readouts purchased for the machines were part of a general move to upgrade the quality of the machines. Only part of their cost was attributable to metric. On the exhibit, only the marginal metric cost -- $60 -- is noted. The tooling and gauging purchased under the metric program would have been purchased eventually as new tooling and gauging were required. The metric program only accelerated the purchase.

IMPCO turned to its regular machinery, tooling, and gauging suppliers for its metric parts. To hasten the spread of metric within the plant, IMPCO arranged for a major tool manufacturer to hold a discount sale for metric tools at the plant. The discount was approximately 30%. Exhibit 11 is a list of the products offered at the sale. IMPCO set up a payroll deduction plan to help the workers pay for the tools. The response was favorable, and the sale was extended.

Service

IMPCO maintains a national organization to repair and install its products. The Service Department has 13 full-time workers and 25 others (trained by Ingersoll-Rand) who can be called on for emergencies. These employees perform about 40% of their work in metric. Their primary functions are installation and start-up of IMPCO machines. Routine maintenance work is handled by the customer. IMPCO does get a few service calls on its installed machines.

IMPCO service personnel have no problems working with metric. They do not care if the machinery is conventional or metric. IMPCO machinery has warnings affixed to remind service and maintenance personnel that metric parts are used (see Exhibit 12).

Exhibit 10

IMPCO'S METRIC PROGRAM

FUNCTIONAL LOCATIONS IN IMPCO'S MANUFACTURING FACILITY
SUCH AS TOOL CRIB, LATHES, OR WELD SHOP

TOOLS	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	Total Qty.	1975$ Per Unit	Total Dollars
'.D. Mike Set 450-600MM	2	2	2	2	2	2	2	2	2	2	2	2	2	2	28	350	9,800
" 1000MM						2		1	1						4	1500	6,000
" 1500MM						2		1	1						4	1500	6,000
ike Standards Set								1	1	1				2	5	60	300
.D. Mikes 00MM	1	1	1	1	1		1	2	1	1	1	1	1	2	15	80	1,200
" 200-800MM	1	1	1	1	1		1	2	1	1	1	1	1	2	15	80	1,200
" 100-1000MM	1	1	1	1	1		1	2	1	1	1	1	1	2	15	80	1,200
epth Mikes 0-150MM(S.B.)	1	1	1	1	1		1	2	1	1	1	1	1	1	14	75	1,050
" 0-150MM (L.B.)	1	1	1	1	1		1	2	1	1	1	1	1	1	14	75	1,050
epth Mikes 0-225MM (S.B.)	1	1	1	1	1		1	2	1	1	1	1	1	1	14	80	1,120

IMPCO'S METRIC PROGRAM

FUNCTIONAL LOCATIONS IN IMPCO'S MANUFACTURING FACILITY
SUCH AS TOOL CRIB, LATHES, OR WELD SHOP

TOOLS	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	Total Qty.	1975 $ Per Unit	Total Dollars
·pth Mikes -225MM (L.B.)	1	1	1	1	1		1	2	1	1	1	1	1	1	14	80	1,120
·dius Gages	1	1	1	1	1		1	2	2	1				1	12	8	96
pes				400	TAPES		@	$3.00							400	3	1,200
ales 150MM																	
" 300MM								2				1		1	4	5	20
" 600MM								2				1		1	4	8	32
" 1000MM								2				1		1	4	25	100
" 1500MM								2				1		1	4	25	100
al Indicators								4	6	2				2	12	60	720
l Indicators Machines)	10	10	10	10	10		10	5	6	4	10	10	10	4	109	60	6,540

FUNCTIONAL LOCATIONS IN IMPCO'S MANUFACTURING FACILITY
SUCH AS TOOL CRIB, LATHES, OR WELD SHOP

TOOLS	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	Total Qty.	1975$ Per Unit	Total Dollars
Hoie Gages 0-200MM	1	1			1				1	1				1	6	5000	30,000
Dial Cal. 0-150MM	2	2	2	2	2		2	5	10	2	2	2	2	10	45	65	2,925
Vernier Cal. 150MM									1	1					2	65	130
" 300MM					1			1	1	1				1	5	180	900
" 00MM					1			1	1	1				1	5	275	1,375
" 1000MM					1			1	1	1				1	5	1000	5,000
" 1500MM					1			1	1	1				1	5	1500	7,500
Pitch Mike Set					1				1	1				1	4	750	3,000
O.D. Mike Set 0-300MM	2	2	2	2	2	2	2	2	2	2	2	2	2	2	28	750	21,000
" 300-450MM	2	2	2	2	2	2	2	2	2	2	2	2	2	2	28	300	8,400

Exhibit 10 (continued)

IMPCO'S METRIC PROGRAM

FUNCTIONAL LOCATIONS IN IMPCO'S MANUFACTURING FACILITY
SUCH AS TOOL CRIB, LATHES, OR WELD SHOP

TOOLS	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	Total Qty.	1975$ Per Unit	Total Dollars
Blocks Set Std. (112)								1	2	1				2	6	1600	9,600
Blocks Special (25,50,75,100MM)								1	1	1				1	4	500	2,000
Blocks Special 9 pc, (125-500MM)								1	1	1				1	4	700	2,800
Thread Gages (sets)								1	1	1				1	4	2500	10,000
nd Tools Set							2	SETS			2				2	500	1,000
Combination Set	2	2	2	2	2		2	2	1	1	2	2	2	1	23	8	184
																TOTAL	144,662

Ingersoll-Rand

Exhibit 11

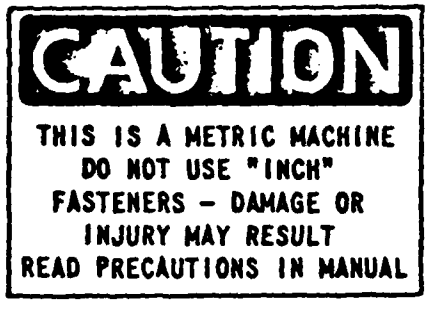
METRIC EMPLOYEE TOOL DISCOUNT PURCHASE PLAN

	ITEM		List Price	% Discount	Employees Price
1.	Metric Starter Kit Direct reading digit micrometers (0-1")0-25mm Bestest Indicator (.001).01mm divisions Dial Calipers (6")0-150mm Case	599-846	$194.60	30%	$136.00
2.	Metric Starter Kit Metric Micrometer (0-1") 0-25mm Metric Micrometer (1-2") 25-50mm Metric Rule (6") 0-150mm Case	599-846-1	$ 99.00	32%	$ 68.00
3.	Metric Starter Kit Metric Micrometer (0-1") 0-25mm Metric Micrometer (1-2") 25-50mm Metric Rule (6") 0-150mm Case	599-846-2	$ 87.00	34%	$ 58.00
4.	Metric Starter Kit Special Metric Micrometer (0-1") 0-25mm Bestest Indicator (.001) .01mm divisions Dial Calipers (6") 0-150mm Metric Rule (6") 0-150mm Case	599-846	$171.10	28%	$123.50
5.	Metric Dial Calipers (6") 0-150mm	599-579-10	$ 69.50	28%	$ 54.00
6.	Metric Bestest Indicator (0.01mm divisions)	599-7031-10	$ 52.00	26%	$ 38.50
7.	Metric Bestest Indicator (0.01mm divisions)	599-7030-10	$ 46.50	27%	$ 34.00
8.	Metric Micrometer (0-1") 0-25mm 0.002mm divisions	599-1-101	$ 35.50	25%	$ 26.50
9.	Direct Reading Digital Micrometers (0-1") 0-25mm 0.002 divisions	599-10-100	$ 59.00	34%	$ 39.00

Exhibit 12

METRIC LABELS ON IMPCO PRODUCTS

WARNING LABELS ARE AFFIXED TO METRIC ASSEMBLY DRAWINGS TO CAUTION AGAINST INTERCHANGE OF METRIC AND INCH FASTENERS



Summary

Metric fits comfortably into the ways IMPCO deals with its suppliers of production parts and production machinery. IMPCO service personnel have not had any problems as a result of the conversion of their equipment. There were a few initial problems with production parts' costs, availability, and quality. These passed quickly. Metric conversion accelerated the upgrading of IMPCO's production machinery and the purchasing of tooling and gauging. Metric is now a routine aspect of IMPCO's business -- inside and with outside suppliers.

IID. EFFECTS OF IMPCO'S CONVERSION ON ITS SUPPLIERS

Introduction

Has IMPCO's conversion affected its suppliers? The previous section described the effects of conversion on IMPCO's relation with its suppliers. This section covers the effect of conversion on the suppliers. Before turning to the suppliers' view on IMPCO's conversion, the section describes IMPCO's view of its impact on suppliers.

IMPCO's View of the Effects of its Conversion on Suppliers

IMPCO does not feel its conversion has affected its suppliers in any lasting way. Almost all their suppliers work in customary dimensions to produce IMPCO's metric products. The only investment the suppliers make in metric production is time and the cost of a calculator for conversions. Suppliers had a few problems with metric at first, but they rapidly accommodated to it. They have not accommodated by working in metric -- only by being more careful in their conversions.

IMPCO does not think it has the power to force anyone to invest in metric conversion. Their orders are very small compared to other large corporations -- such as General Motors, General Electric, Caterpillar, IBM, and others. These firms increase the market availability of metric parts. IMPCO benefits from this increased availability.

Suppliers' Views on the Effects of IMPCO's Conversion

IMPCO's suppliers support IMPCO's view of its impact -- few problems, few costs, few benefits, and continued production using customary units. These observations are based on contacts with 25 small manufacturers (independent businesses with less than 500 employees) of metric products for IMPCO. These 25 companies came from a more extensive list of companies including 47 big (over 500 employees) or foreign companies, 13 distributors, 8 small manufacturers working only in customary, and 9 small manufacturers producing metric products for companies other than IMPCO. The team asked the 25 small manufacturers supplying metric parts to IMPCO about the costs, benefits,

problems, and opportunities associated with converting to metric.

The companies producing metric products for IMPCO range from a 9 employee casting producer to a 400 employee foundry and machine shop. The average small metric supplier to IMPCO has 145 employees; half the companies have 115 employees or fewer (see Exhibit 13). Most of the companies are located in Massachusetts or Connecticut; others are in Ohio, Pennsylvania, New York, Wisconsin, and New Hampshire. Of the 25, 12 make castings. The remaining 13 produce springs, machined parts, forgings, gears, plates, welds, or shafts.

Suppliers making metric parts for IMPCO devote little of their production to metric. Half of the firms produce 5% or fewer of their products to metric dimensions; the average is 10% (see Exhibit 14). None of IMPCO's metric suppliers produce over 30% of their products to metric dimensions.

IMPCO accounts for a small fraction of its suppliers' low level of metric activity. Half the suppliers do 10% or less of their metric work for IMPCO (see Exhibit 15). Relating the percentage of metric work accounted for by IMPCO with the percentage of total production in metric (Exhibit 16) shows the lack of IMPCO's effect on its metric suppliers more clearly. All four firms for whom IMPCO accounts for over 75% of metric production devote less than 25% of their production to metric. Of these four, three devote 2% or less; the other one devotes 10% of its production to metric. Of the three firms with over 25% of their total production in metric, IMPCO accounts for 1%, 5%, and 10% of their metric production.

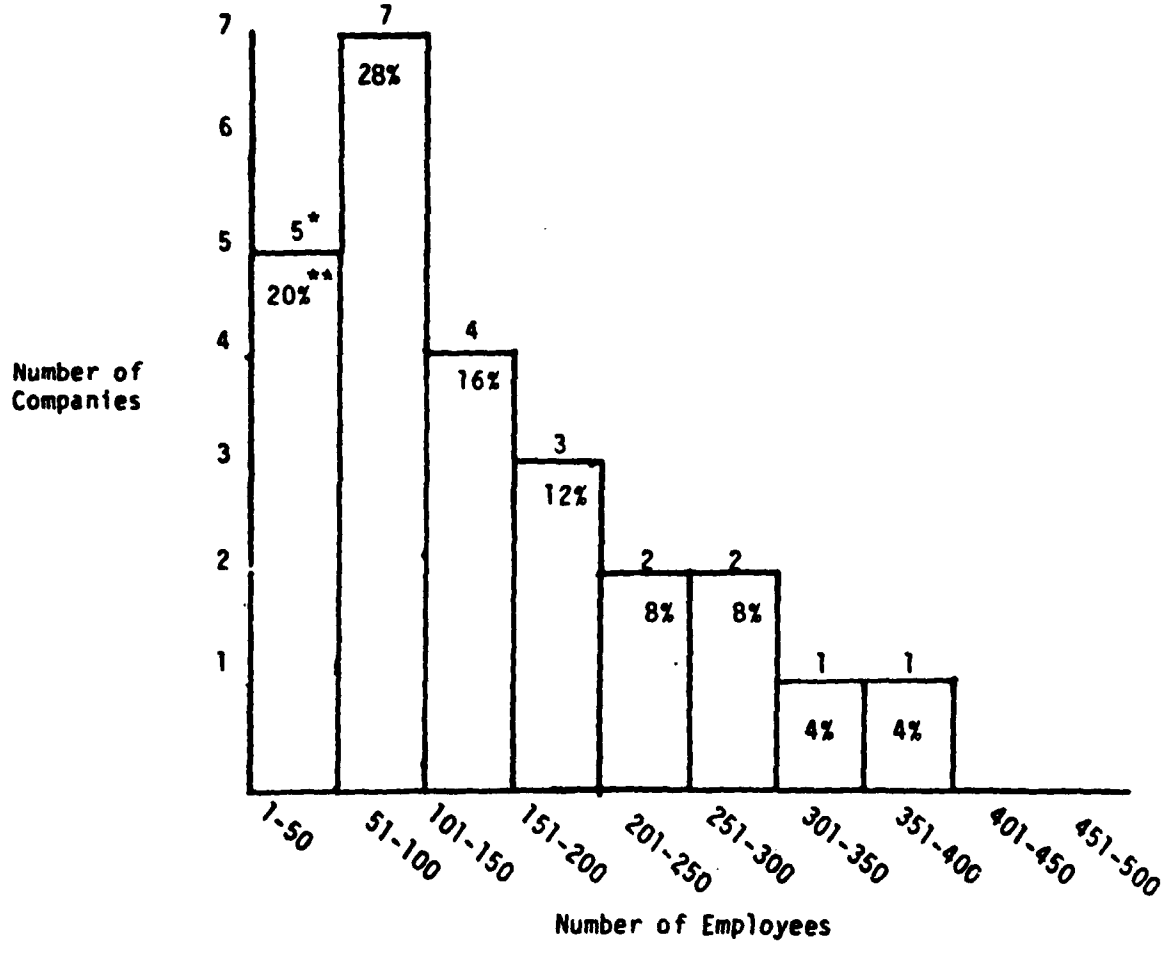
Suppliers to IMPCO also supply metric products to other customers. These include Brown and Sharp (a tool manufacturer), International Shoe Machine, Simplex Wire and Cable, machine tool builders, ship builders, pump and valve companies, and foreign customers.

To make metric products, IMPCO's suppliers do not make substantial investments. None spent over $5,000. Half spent nothing. Most investments made were for inspection equipment. Some firms spend large amounts for metric tooling but recover those tooling costs from their customers. One company spends hundreds of thousands of dollars on metric tooling each year. Its customers provide the initial tooling, but as that tooling wears out, the company must purchase replacement tooling. The costs of that replacement tooling are passed on to

Exhibit 13

SMALL METRIC MANUFACTURERS

NUMBER OF EMPLOYEES



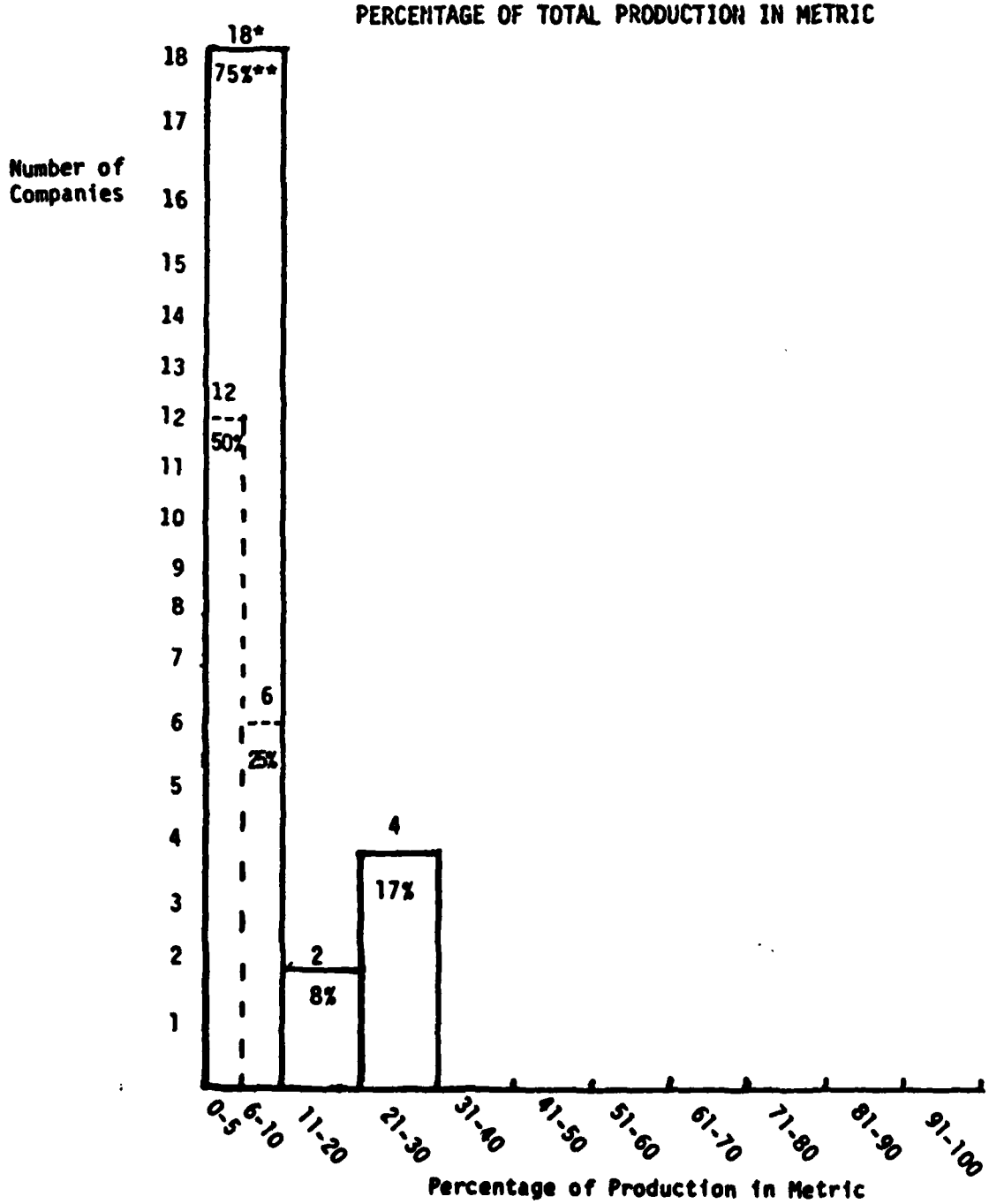
Average = 145
Median = 115
Total number of companies = 25

* Number of companies in each category.
** Percentage of total number of companies in each category.

Exhibit 14

SMALL METRIC MANUFACTURERS

PERCENTAGE OF TOTAL PRODUCTION IN METRIC



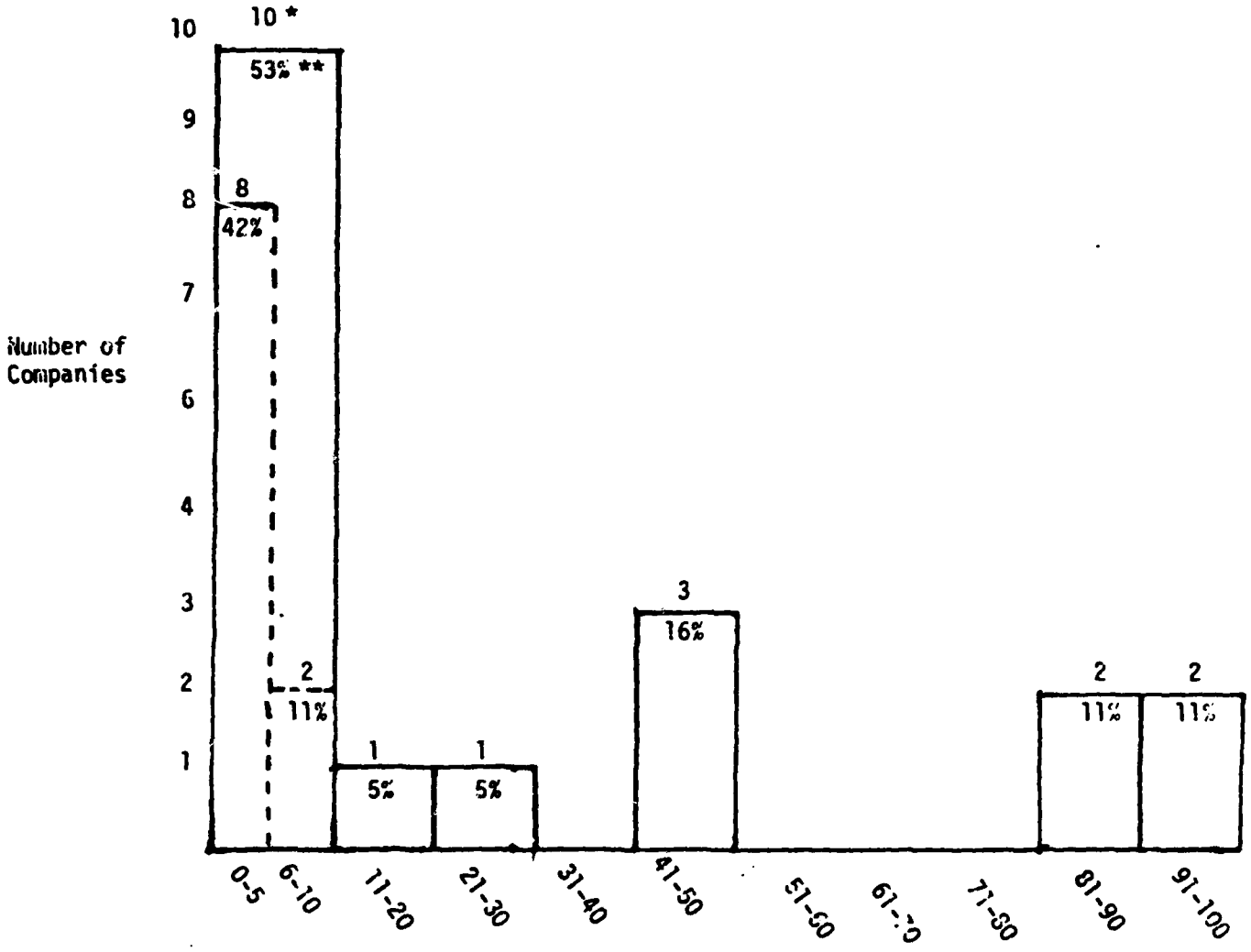
Average = 10%
Median = 6%
Total number of companies = 24

* Number of companies in each category

** Percentage of total number of companies in each category

Exhibit 15

SMALL METRIC MANUFACTURERS
PERCENTAGE OF METRIC PRODUCTION RELATED TO IMPCO



Average = 32%
Median = 10%
Total Number of Companies = 19

* Number of companies in each category
** Percentage of total number of companies in each category

Exhibit 16

SMALL METRIC MANUFACTURERS

RELATION OF PERCENTAGE OF METRIC ACCOUNTED FOR BY IMPCO WITH PERCENTAGE OF PRODUCTION IN METRIC

Percent of Total Production in Metric	Percent of Metric Production Related to IMPCO				
	0-24%	25-49%	50-74%	75-100%	Total
0-24%	8 (42%)	1 (5%)	3 (16%)	4 (21%)	16 (84%)
25-49%	3 (16%)	0	0	0	3 (16%)
50-74%	0	0	0	0	0
75-100%	0	0	0	0	0
Total	11 (58%)	1 (5%)	3 (16%)	4 (21%)	19 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

the customers in the piece cost of the products. The company would incur the same tooling costs if the product was made to customary dimensions.

Exhibit 17 shows how the suppliers to IMPCO produce metric parts. A substantial number of suppliers (36%) work in metric or work in metric and customary to produce metric parts. However, 56% continue to work in customary. The pattern does not change when percentage of total production in metric is considered; three of the four firms doing over 25% of their work in metric continue to work in customary (see Exhibit 18). Of the five firms working in metric, four devote 10% or less of their production to metric.

The low level of metric activity among IMPCO's suppliers has created few problems for IMPCO's metric suppliers. Of the 25 companies, three noted problems with getting metric supplies; another mentioned resistance among employees. Suppliers also do not see any benefits from converting to metric. One company said its overseas business has expanded. Others said converting only served to keep current customers' business. Most saw no benefit from converting to metric.

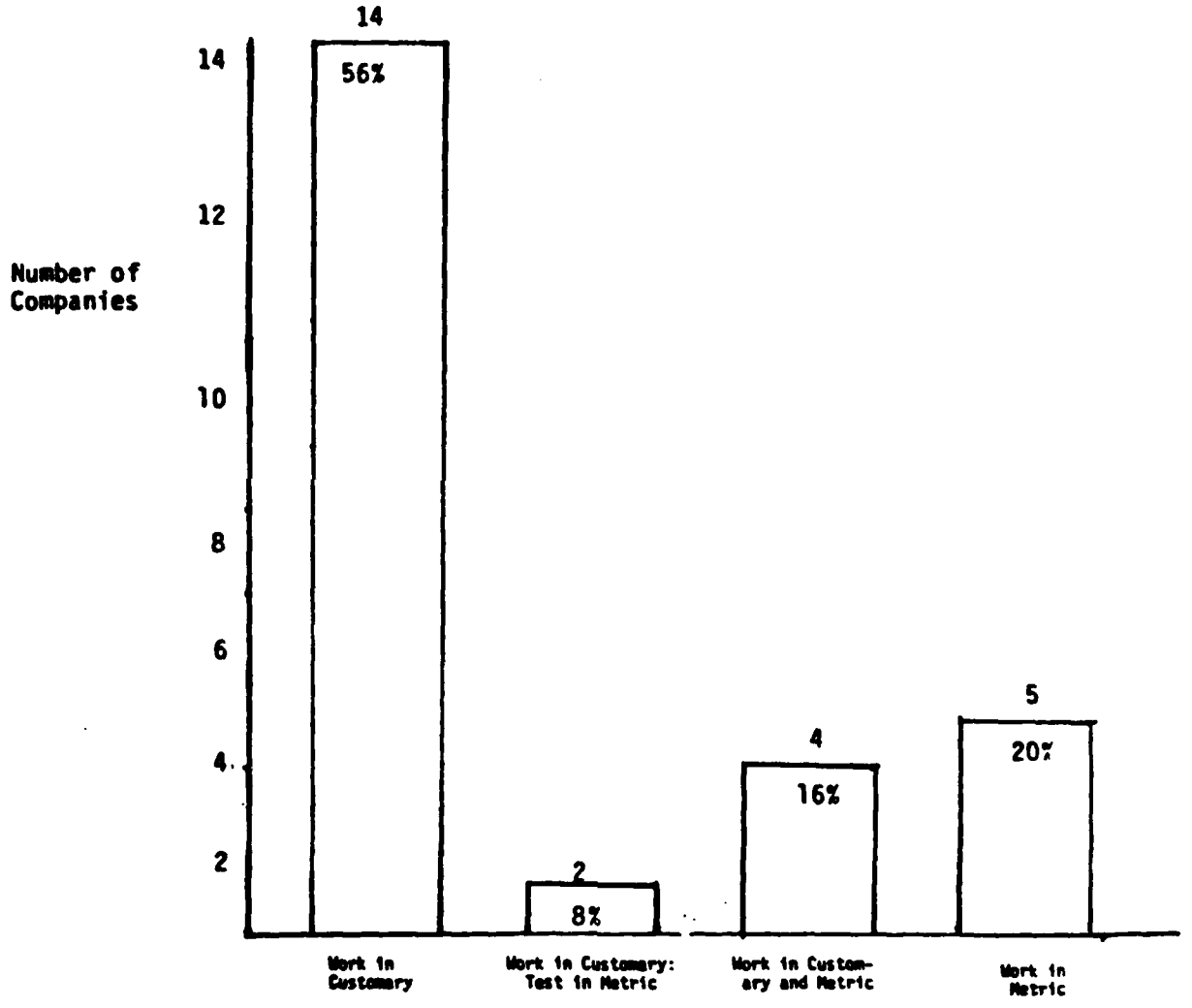
Summary

IMPCO and its metric suppliers agree that IMPCO's conversion has been easily accommodated by suppliers. Exhibit 19 summarizes the suppliers' experiences. IMPCO's orders for metric are small; similarly, suppliers' involvement in metric is quite small. Most companies choose to deal with the occasional metric order by converting to customary. Few firms invest in developing a metric capability; the demand for metric among their customers does not warrant it. The metric suppliers to IMPCO see few problems from conversion. They also see few benefits from conversion.

Exhibit 17

SMALL METRIC MANUFACTURERS

METHOD OF METRIC PRODUCTION



Total number of companies = 25

Exhibit 18

SMALL METRIC MANUFACTURERS

RELATION OF METHOD OF METRIC PRODUCTION
WITH PERCENTAGE OF PRODUCTION IN METRIC

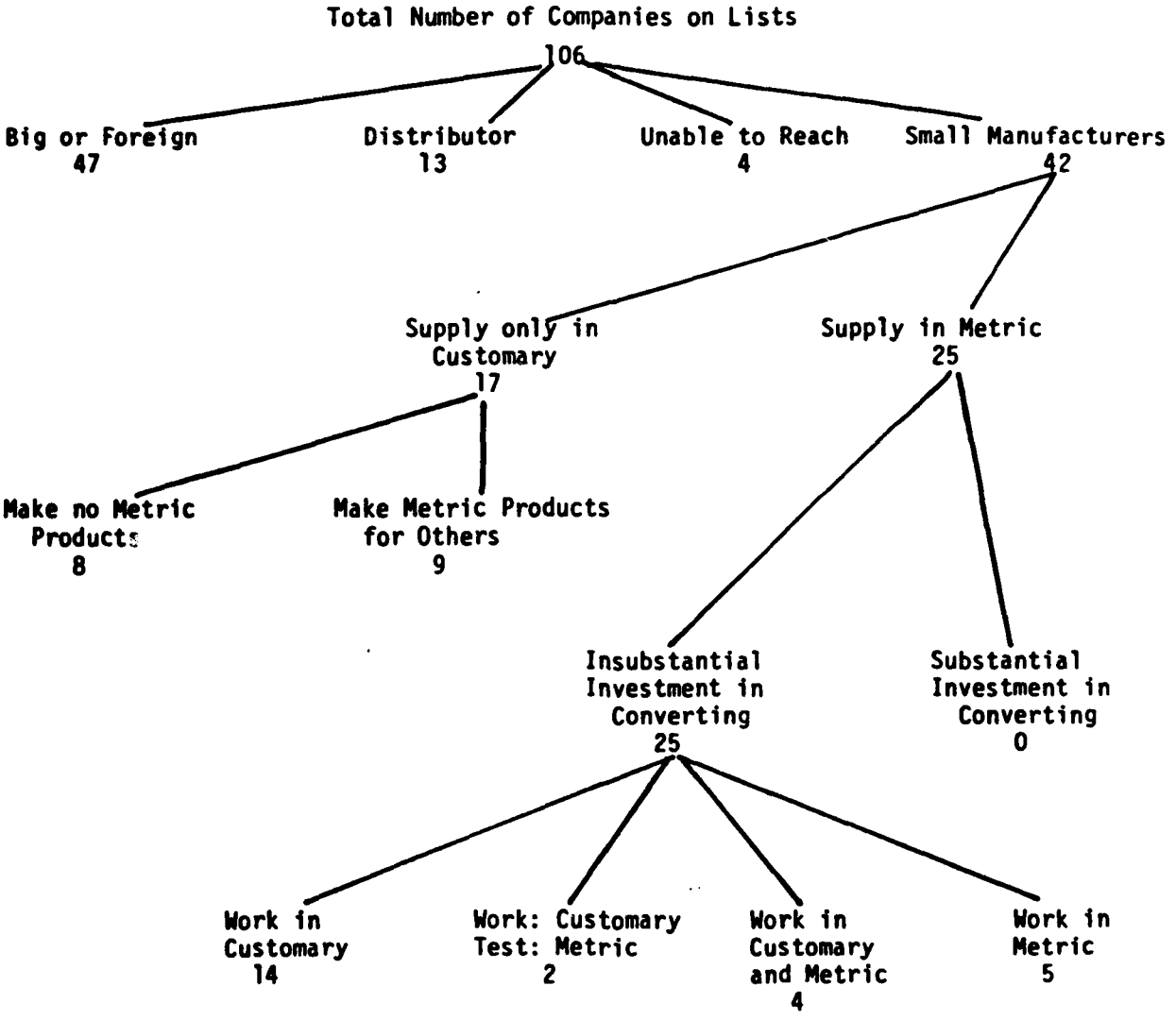
Method of Metric Production

Percent of Total Production in Metric	Work in Customary	Work in Customary: Test in Metric	Work in Customary and Metric	Work in Metric	Total
0-24%	10 (42%)	2 (8%)	4 (17%)	4 (17%)	20 (83%)
25-49%	3 (13%)	0	0	1 (4%)	4 (17%)
50-74%	0	0	0	0	0
75-100%	0	0	0	0	0
	13 (54%)	2 (8%)	4 (17%)	5 (21%)	24 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

Exhibit 19

METRIC ACTIVITY IN IMPCO SUPPLIERS



IIIA. PORTABLE COMPRESSOR SUMMARY

General Finding

Metric fits comfortably into the relations between Portable Compressor Division and its suppliers and into the operations of the suppliers. Portable Compressor has taken a cautious, gradual approach to converting to metric. This resulted in few problems or investments for its suppliers to meet Mocksville's metric needs. Half of Portable Compressor's suppliers do less than 5% of their metric work for Mocksville. The only problems with metric have been errors on conversion tables resulting in unsuitable parts; these errors were encountered only in the initial stages of conversion. Mocksville has not dropped any suppliers; they have added a few distributors of metric hardware. Suppliers see few problems or benefits from Portable Compressor's conversion.

The Case Study

The general firding above and the detailed findings below come from a case study of Portable Compressor's conversion to metric. The case study looks into how small businesses respond to large corporations' needs. Large customers' demands often drive small business conversion.

Previous research led to hypotheses about the interaction among large and small businesses on metric. The study team investigated these hypotheses through interviews with the appropriate Portable Compressor departments and contacts with 127 small manufacturers.

Detailed Findings

The detailed findings are:

- Many small manufacturers working for Portable Compressor produce metric products. Of the 127 contacted, 50% produce metric products for Mocksville. Another 22% produce metric products for other customers but not for IMPCO.

- Half of the small metric manufacturers supplying Mocksillve have 58 or fewer employees; the average has 90.

- Portable Compressor's metric suppliers do little of their work in metric. They average 19% of production to metric dimensions. Half do 15% or less of their work in metric.

- Portable Compressor has few metric orders -- less than a third of its parts. Therefore, Mocksville is not a major factor in forcing its suppliers to convert to metric. Half of Portable Compressor's metric suppliers do less than 5% of their metric work for Mocksville.

- Suppliers invest very little to convert to metric. Of the 65 metric suppliers, a third said they had spent nothing. Of the other two-thirds, four spent more than $5,000 but less than $10,000 on tooling and quality control equipment.

- Portable Compressor's suppliers produce metric products either using customary dimensions (42%), or customary and metric dimensions (41%). Very few (3%) work only in metric; 14% produce in customary but inspect in metric dimensions.

- Few suppliers report problems or benefits from conversion. Several companies mentioned problems with getting metric supplies. Two companies said there was less competition for metric orders.

- Portable Compressor has had slight problems with parts made to its drawings. Initially, errors on conversion tables led to defective parts from suppliers and from internal manufacturing.

IIIB. PORTABLE COMPRESSOR BACKGROUND

What is Portable Compressor Division?

Portable Compressor is a division of Ingersoll-Rand employing under 1000 people. This division makes air compressors for industry -- such as compressors which are pulled behind trucks and used at construction sites. The Portable Compressor plant -- a 33,000 square meter facility (about 350,000 sq. ft.) -- is located in Mocksville, North Carolina.

Mocksville's air compressors have five basic assemblies:

- frame and running gear -- which support the compressor;
- cover - to protect the compressor;
- control section - that regulates the compressor;
- engine - to power the air end;
- air end - the portion that takes the air in, compresses it, and discharges it.

Exhibit 20 illustrates the key parts of the portable compressor. Many of the compressors sell for between $10,000 and $20,000. These popular compressors, shown in Exhibit 21, account for 80% of Mocksville's sales.

Suppliers manufacture the frame, cover, engine, and much of the control section of the compressor. Portable Compressor Division makes the air-ends of the compressors. They design and assemble all these components into a portable compressor package.

Metric Conversion at Portable Compressor Division

Portable Compressor has adopted a cautious, wait and see attitude toward metric conversion. Mocksville began its metric conversion program in 1973. By 1976, Portable Compressor had developed its policy toward metric; the key elements of the policy were:

- Conversion only where technically and economically practical.
- Different pace of conversion for different types of parts; they distinguish between parts designed and made by Mocksville, parts designed by Mocksville and made by other companies, and products designed and made by other companies (proprietary products).

Exhibit 20

MAJOR SECTIONS OF A PORTABLE COMPRESSOR

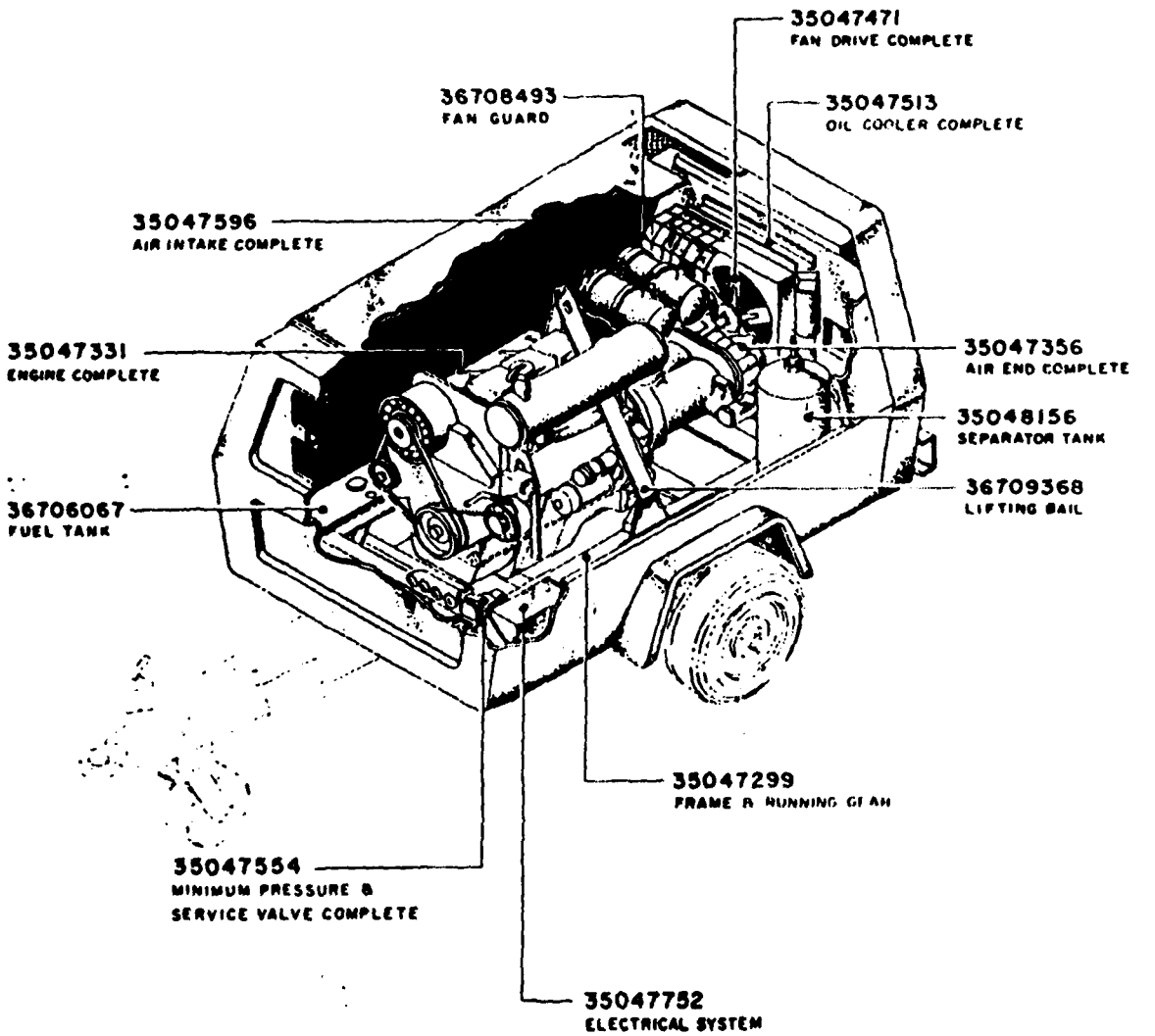
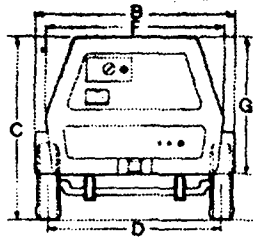
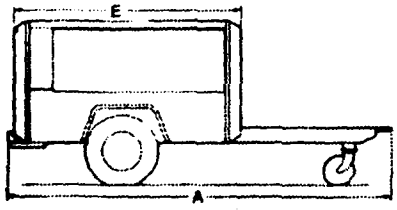


Exhibit 21

THE BEST SELLING MOCKSVILLE COMPRESSORS

Specifications—P-100, P-175 and P-185 portable compressors

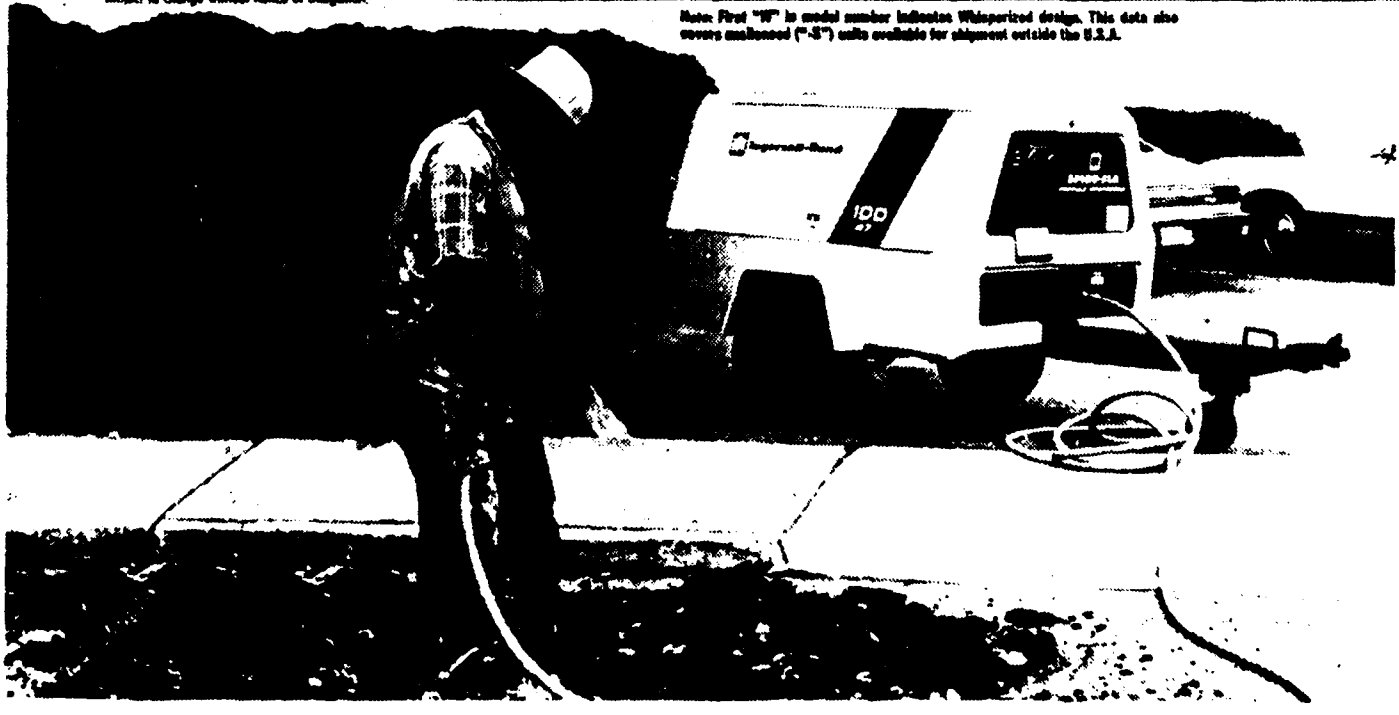




Note: Product improvement is a continuing goal of Ingersoll-Rand. Design and specifications are subject to change without notice or obligation.

	Compressor with gasoline engine		Compressor with diesel engine		Compressor with gasoline engine		Compressor with diesel engine		Compressor with diesel engine	
	U.S.	Metric	U.S.	Metric	U.S.	Metric	U.S.	Metric	U.S.	Metric
Model	P-100-W-W		P-100-W-D		P-175-W-W		P-175-W-D		P-185-W-JD	
ENGINE	White, water-cooled		Deutz, air-cooled		White water-cooled		Deutz, air-cooled		John Deere, water-cooled	
Model	G-1600X		F2L912		G 1600		F3L912		4219D	
Number of cylinders	4		2		4		3		4	
Bore x stroke (inches)	4 x 3.25		3.94 x 4.72		4 x 3.25		3.94 x 4.72		4.92 x 4.33	
Rated speed, rpm	2500		2500		2500		2500		2500	
Available hp. at rated speed	40		33		61		54		70	
COMPRESSOR										
Actual free-air Delivery	100 cfm	47 L/s	100 cfm	47 L/s	175 cfm	80 L/s	175 cfm	80 L/s	185 cfm	90 L/s
Rated oper. pressure	100 psig	7.0 kg/cm²	100 psig	7.0 kg/cm²	100 psig	7.0 kg/cm²	100 psig	7.0 kg/cm²	100 psig	7.0 kg/cm²
Max. pressure	120 psig	8.4 kg/cm²	120 psig	8.4 kg/cm²	120 psig	8.4 kg/cm²	120 psig	8.4 kg/cm²	120 psig	8.4 kg/cm²
UNIT WITH RUNNING GEAR										
Length incl. towbar (A)	127"	3230 mm	127"	3230 mm	144"	3636 mm	144"	3636 mm	144"	3636 mm
Width overall (B)	60"	1524 mm	60"	1524 mm	75"	1905 mm	75"	1905 mm	75"	1905 mm
Height (C)	56"	1417 mm	56"	1717 mm	58"	1473 mm	58"	1473 mm	58"	1473 mm
Track width (D)	52"	1321 mm	52"	1321 mm	64"	1626 mm	64"	1626 mm	64"	1626 mm
Weight, ready to run	2010 lb.	910 kg	2330 lb.	1050 kg	2305 lb	1045 kg	2785 lb.	1265 kg	2670 lb	1211 kg
UNIT LESS RUNNING GEAR										
Length (E)	76"	1930 mm	76"	1930 mm	92"	2340 mm	92"	2340 mm	92"	2340 mm
Width (F)	53.5"	1359 mm	53.5"	1359 mm	53.5"	1359 mm	53.5"	1359 mm	53.5"	1359 mm
Height (G)	42"	1067 mm	42"	1067 mm	42"	1067 mm	42"	1067 mm	42"	1067 mm
Weight, ready to run	1710 lb.	775 kg	2030 lb.	920 kg	2000 lb	905 kg	2485 lb.	1120 kg	2370 lb	1070 kg

Note: First "W" in model number indicates Wisperized design. This data also covers enclosed ("-S") units available for shipment outside the U.S.A.



- Conversion charts (metric with inch equivalents) on all drawings until internal manufacturing and outside suppliers have 100% metric capability.
- Air ends designed in metric, other parts designed in customary and converted to metric (soft metric design) only until 1980; after that all products to be designed in hard metric.
- Specify metric where practical and available on proprietary products.
- Request suppliers to convert at least on those parts attaching to other parts to accommodate metric interface.

Portable Compressor's movement into metric conversion has been slower than anticipated in 1976. All of the air ends with some system components are designed in metric units. The air end has always been designed in metric as it is designed and manufactured under license from a foreign company.

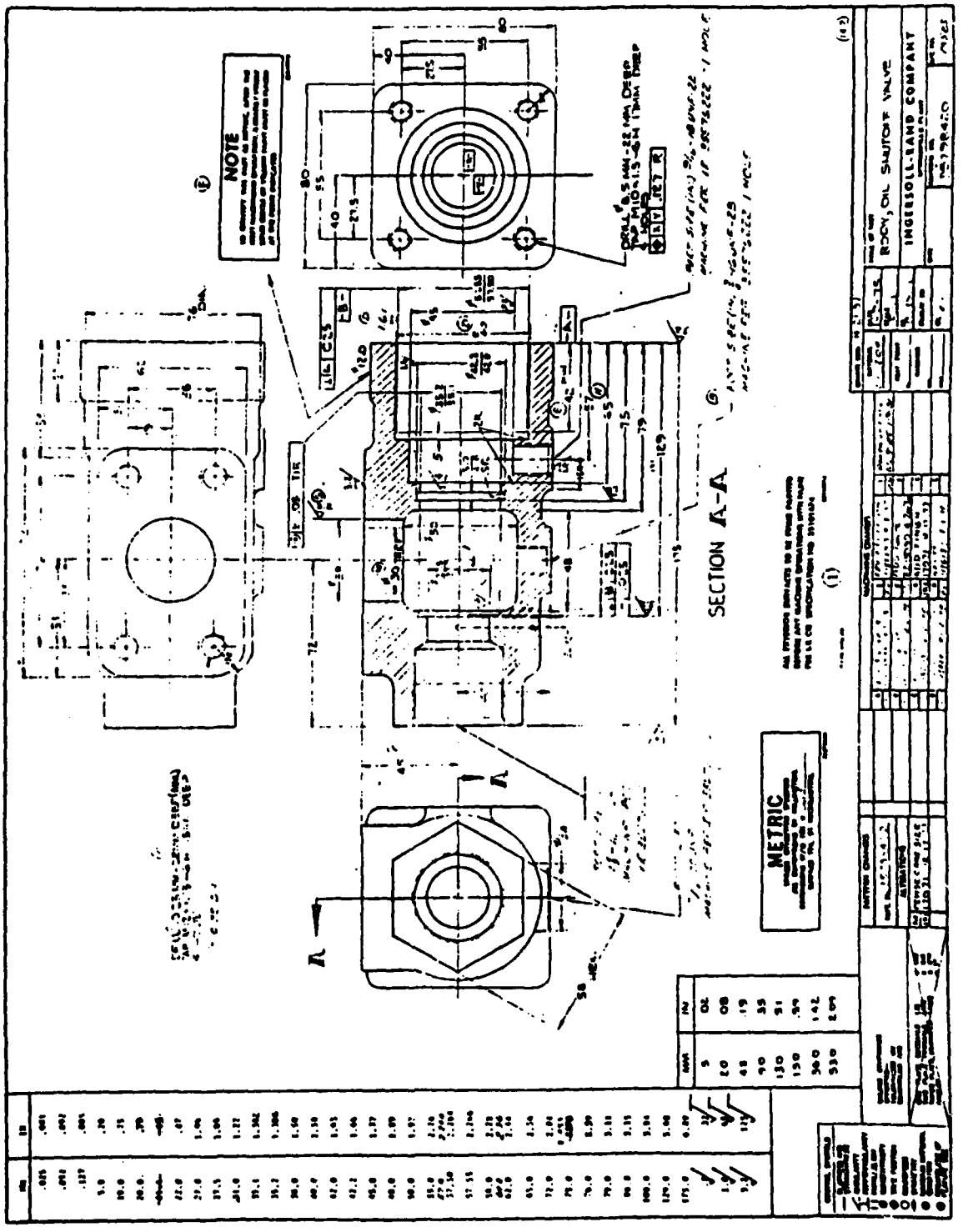
The metric designed components of the portable compressor are manufactured in customary units as only a limited number of manufacturing machines are capable of working in metric units. All of Mocksville's metric drawings have millimeter to inch conversion tables (see Exhibit 22). In late 1978, Mocksville Engineering Department attempted to drop the inch equivalents because there were some conversion errors. The Manufacturing Department was not prepared and asked that the conversion tables be reinstated. Suppliers did not comment one way or the other on the dropping of inch equivalents.

Portable Compressor chose to go slowly on the corporate program to convert to metric. Their conversion has focused on the compressor unit which originated in Europe and is now designed and manufactured under license. To produce metric products, Portable Compressor works in customary units. Therefore all their drawings have conversion tables on them.

Exhibit 22

A PORTABLE COMPRESSOR DRAWING

(Note Conversion Chart on Left)



IIIC. METRIC CONVERSION AND PORTABLE COMPRESSOR'S RELATIONS WITH SUPPLIERS

Introduction

This case study of small business-large business interaction follows two paths -- the effects of conversion on small business suppliers and customers and the effects of metric conversion on the way the large company relates to its suppliers. Relations with suppliers refer to:

- Involvement of suppliers in design decisions;
- Effect on design of customer and service organization considerations;
- Effect on design and production of supplier capabilities;
- Interaction and the relative importance of different divisions dealing with small suppliers;
- Primary considerations for each department in its relations with suppliers.

To find how metric conversion affected the way Portable Compressor deals with its suppliers, the team first developed an overview of the way a product normally is designed, produced, and serviced. With that background, the team looked for changes resulting from conversion.

Portable Compressor has handled metric conversion easily with few difficulties. Metric fits into established patterns of dealing with suppliers. The only problem has been a slight increase in errors on parts as a result of errors in conversion tables on Portable Compressor drawings. This section describes the stages of the product lifecycle at Portable Compressor and how metric has affected each stage.

Suppliers and the Portable Compressor Lifecycle

Suppliers are involved in many phases of the design, production, and servicing of Portable Compressor products. However, different steps in the movement from design to service involve different Portable Compressor departments, different types of suppliers, and different considerations dominating relations between Portable Compressor and the outside supplier. These differences are important to understanding how metric conversion affects the way Portable Compressor looks at and deals with its suppliers.

Four stages in the movement from concept to product service involve suppliers:

- Prototypes and Pre-production Runs - To prove a concept and improve design, Mocksville's engineering department builds prototypes of final products. Some parts must be supplied by outside suppliers for these prototypes. Mocksville also makes pre-production runs after the prototype stage, to establish manufacturing methods.
- Parts for Production - Outside suppliers make parts for Portable Compressor's finished product. Some parts are standard items such as nuts and bolts; others are unique or custom parts designed for that product, such as metal brackets for supporting equipment.
- Production Equipment - To make a new product, Portable Compressor may need new machines or new capabilities on existing machines. Mocksville may purchase these machines or capabilities from outside suppliers.
- Product Service - After a product leaves Mocksville it may during its lifetime, require repair, modification, or rebuilding. Distributors, customers, or other service organizations normally do these service tasks.

Departments in Portable Compressor which deal with suppliers are:

- Design and Development Department * develops concepts and detailed drawings of new products. It has its own purchasing department -- Development Purchasing -- for buying parts necessary for building prototypes and pre-production runs in small numbers.
- Manufacturing Engineering tools and methodizes all internal production. They determine if a product can be made internally or must go to outside suppliers; they also identify the need for new capabilities or new machines for in-house production.
- Quality Control is part of Manufacturing Operations. They audit in-house and supplier parts against engineering specifications.
- Purchasing identifies, selects, and orders from suppliers. They have the most contact with suppliers.
- Product Service trains service personnel, and works to ensure serviceability is integrated in design.

The following sections describe how metric fits comfortably into the patterns of relations between Mocksville and its suppliers. These

*These brief descriptions only refer to those activities of these departments of direct relevance to supplier relations.

descriptions cover the product lifecyle from prototype to product service -- a lifecycle involving hundreds of Mocksville employees, hundreds of suppliers, and many years, depending on the lifetime of the product.

Prototypes

Design and Development department and Development Purchasing handle the development of prototypes and pre-production runs. Development Purchasing works with suppliers to find parts and make purchases for prototypes and pre-production runs. Purchasing often uses the suppliers identified and used by Development Purchasing when it buys parts for full production runs. Sometimes Purchasing finds new suppliers that can provide the parts at lower cost or with better service than the original supplier.

Purchasing of prototypes and pre-production parts has not changed as a result of metric conversion. Development Purchasing uses the same suppliers it did before metric conversion. They may have added a few metric hardware distributors. They have not had problems with conversion errors or rejected parts as a result of metric conversion.

Where possible the Development Purchasing department uses standard parts. On parts designed by Mocksville and manufactured by outside companies, they encountered some initial confusion regarding metric; several suppliers called with questions about tolerances and dimensions. Those problems did not last long.

To find metric suppliers, Development Purchasing does a "ground up" search using standard catalogs to locate the parts they need. They could buy a catalog file specializing in metric suppliers, but they estimate they can do their own searches for less cost. The types of suppliers used by Development Purchasing include die casters, gray iron casting firms, sheet metal fabricators, fastener distributors, gear manufacturers, metal stampers, and plastic injection molders.

Parts for Production

In their conversion plan Portable Compressor identifies three types of products affected by conversion:

- products designed and made by outside suppliers (proprietary parts), such as heat exchangers, gauges, and fasteners;
- products designed and produced by Mocksville, such as air ends, valves, and regulators;
- products designed by Mocksville and made by outside suppliers, such as frames and housings.

The first are standard items. These may be customized to meet Portable Compressor's needs, but they are basically standard items. Products designed by Portable Compressor are unique parts. The maker of the product depends on several factors, such as costs, capacity, capability, and lead times. The following sections describe the implications of metric for standard and unique parts made by outside suppliers. The next section describes the effects of Mocksville's conversion on its own production of unique parts.

Standard Parts

In purchasing standard parts, Portable Compressor looks for the best quality product at the lowest cost. Sometimes they have a sole source arrangement with suppliers for a particular product; usually these are for electronic or other types of highly specialized equipment. About one-third of the products Mocksville purchases come from sole source purchases.

Mocksville prefers to use a number of sources of supply for all parts. Purchasing reviews Development Purchasing's prototype and pre-production suppliers in terms of price, availability, and quality.

For many standard parts -- especially fasteners -- Mocksville may use local distributors instead of manufacturers. Distributors offer flexibility and shorter lead times due to their inventory levels; a manufacturer may take a number of weeks and require a larger order.

Metric has not changed the way Mocksville purchases standard parts. Mocksville has not converted certain parts to metric because conversion would restrict sourcing and reduce price competition. On other standard parts, such as fasteners, Portable Compressor has added a few metric distributors. Some of their regular local suppliers have begun to stock metric products.

Unique Parts

Manufacturing Engineering Department decides whether a unique part will be made by Mocksville or an outside supplier. The decision to make or buy a part depends on:

- Capacity - The most important of the three, this refers to the amount of available machine time for making the part. If the plant or the machine tool is already working close to capacity, Mocksville may turn to a supplier.
- Capability - Mocksville may not have the machinery to make a certain type of part such as a screw machine part. If they use only a few of these parts, buying the product from a supplier would cost less than buying the capability.
- Cost - Mocksville looks for suppliers who can make the product at a lower cost than they can. They rarely find such suppliers.

When Mocksville decides to use an outside source, it also has a choice between using a supplier or a subcontractor. A supplier supplies Mocksville with a finished product based on a drawing. They order the raw materials, produce the part, and ship the product to Mocksville. A subcontractor works on semi-finished products such as castings supplied by Mocksville. They are generally responsible for one or two operations such as boring, milling, drilling, or heat treating.

Suppliers make tooling to make the parts ordered by Mocksville. Mocksville pays the cost of this tooling directly or through the piece price. When they pay the tooling costs directly, Mocksville owns the tools. For subcontractors, Mocksville may provide the tooling For example, Portable Compressor may use a subcontractor to handle an overflow of work for a short period of time; they lend the subcontractor the tooling because it is not economical to pay for another set of tools.

After conversion to metric, Mocksville continued to use the same suppliers it did before it converted to metric. Subcontracting or sole-source arrangements have not increased as a result of conversion. Portable Compressor has had problems of errors on Portable Compressor's conversion of metric to customary units. These errors were encountered in the initial stages of conversion on the parts suppliers produce.

Production Equipment

Portable Compressor has over 100 machine tools in its 350,000 square foot facility. Many of these machines have numerical control capabilities. Drawings come from Engineering to Manufacturing Engineering. They determine how the product will be made and send the drawings to the Manufacturing departments. The machine operators use the controls or dials on the machine to make general adjustments in producing the product. The machine operator then inspects the part using micrometers, calipers, and other hand held equipment. The results of the inspections are used for final machine adjustments.

Mocksville works in conventional units to produce metric products. The operators prefer to work in customary. Also, Manufacturing Engineering does not like to mix customary and metric dimensions. Manufacturing has spent very little on metric. Some numerical control machines are equipped with measurement capability. Some machines have digital readouts or dials that allow them to operate in both dimensions.

Internal manufacturing has the same quality control problems with metric as the suppliers. Because of conversion errors on drawings, a part may be manufactured improperly.

Product Service

Three types of organizations service Portable Compressor:

- Small rental yards - Small rental yards tend to do their own repairs with the help of a general purpose mechanic who might work on all types of machinery.
- Ingersoll-Rand distributors - Mocksville trains their personnel.
- Independent equipment dealers - Mocksville does not train these repair persons.

The three organizations have not had any problems working with the metrics in the machinery. Some special tools are required to work on I-R portable compressors; these are not special because they are metric. Portable Compressor is not aware of any complaints from service personnel concerning metric.

Summary

Portable Compressor has taken a gradual, cautious approach to metric conversion. Less than a third of their products are made to hard metric dimensions; all of their new drawings are in metric dimensions but many are soft conversions. Their limited conversion has not affected their relations with suppliers at the prototype, production, or service level. There were some problems with errors in conversion tables on the Mocksville drawings. Overall, metric has presented very few problems to Mocksville in its relationship with its suppliers.

IIID. EFFECTS OF PORTABLE COMPRESSOR'S CONVERSION ON ITS SUPPLIERS

Introduction

Has Portable Compressor's conversion affected its suppliers? The previous section described the effect of conversion on Portable Compressor's relations with its suppliers. This section covers the effects of conversion on the suppliers. Before turning to the suppliers' view on Mockville's conversion, the section describes Mocksville's view of its impact on suppliers.

Portable Compressor's View of the Effects of its Conversion on Suppliers

The Portable Compressor Division thinks most of its suppliers convert its metric dimensioned drawings to customary and work in customary only. They do not have to do much conversion since Portable Compressor provides conversion tables on its drawings. Mocksville does not care how a supplier produces a part as long as the part is accurately and reliably built. Portable Compressor has had problems with suppliers producing metric parts. The rejection rate has been a little higher for parts made from metric dimensionsed drawings.

Suppliers' Views on the Effects of Portable Compressor's Conversion

Suppliers support Portable Compressor's view of its impact -- few problems, few costs, few benefits, and continued production using customary units. These observations are based on contacts with 65 small manufacturers (independent businesses with fewer than 500 employees) of metric products for Portable Compressor. These 65 companies came from a more extensive list, including 54 big (over 500 employees) or foreign companies, 30 distributors,

34 small manufacturers working only in customary, and 27 small manufacturers producing metric products for companies other than Mocksville. The team asked the 65 small manufacturers supplying metric parts to Mocksville about the costs, benefits, problems, and opportunities associated with converting to metric.

The companies producing metric products for Mocksville range from a two-employee prototype supplier to a 450-employee gauge manufacturer. The average small metric supplier to Portable Compressor has 90 employees; half the companies have 58 employees or fewer (see Exhibit 23). About half the companies are located in North Carolina. The others are in Pennsylvania, Ohio, Illinois, New York, Georgia, Wisconsin, and other states. These companies produce many products, including gaskets, cables, decals, tubes, bolts, pistons, castings, stampings, plastic parts, springs, machined parts, forgings, gears, plates, welds or shafts.

Suppliers making metric parts for Portable Compressor do not do much metric work. Half of the firms produce 15% or fewer of their products to metric dimensions; the average is 19% (see Exhibit 24). None of Mocksville's metric suppliers produce over 70% of their products to metric dimensions.

Portable Compressor accounts for a small fraction of its suppliers' metric activity. Half the suppliers do 5% or less of their metric work for Mocksville (see Exhibit 25). Relating the percentage of metric work accounted for by Mocksville with the percentage of total production in metric shows the lack of Mocksville's effect on its metric suppliers more clearly (see Exhibit 26). Of the nine firms who do over 75% of their metric production for Portable Compressor, eight devote less than 25% of their production to metric. For each of the six firms with over 25% of their total production in metric, Portable Compressor accounts for less than 25% of their metric production.

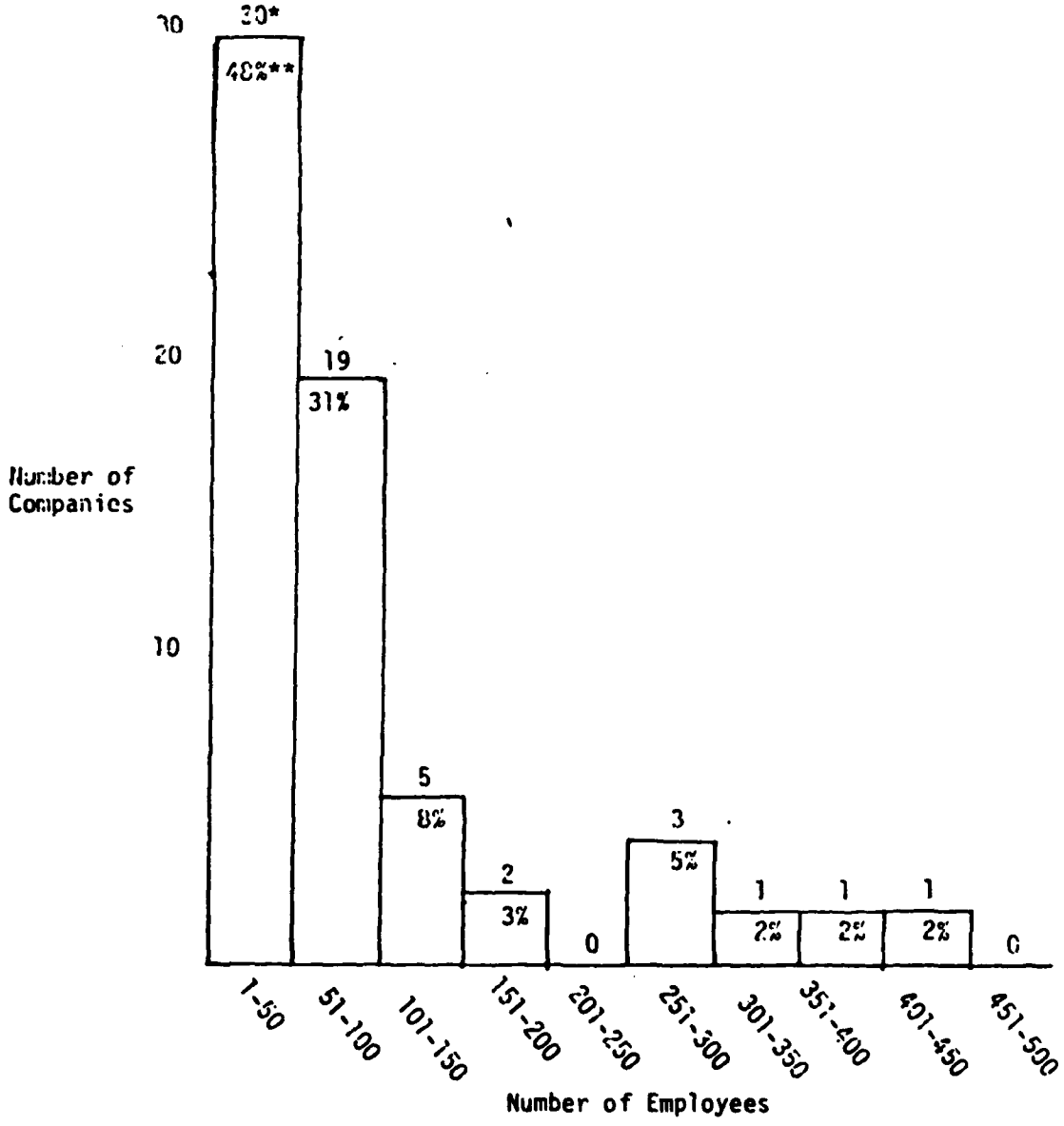
Suppliers to Mocksville also supply metric products to other customers, including: Westinghouse; IBM; automotive; truck; textile and tobacco industries; aircraft industry; office machinery manufacturers; Caterpillar; Firestone; Philip Morris; Delco Machine; Dana Corporation; and General Electric as well as foreign customers.

Exhibit 23

PORTABLE COMPRESSOR'S

SMALL METRIC MANUFACTURERS

NUMBER OF EMPLOYEES



Average = 90
Median = 58
Total number of companies = 62

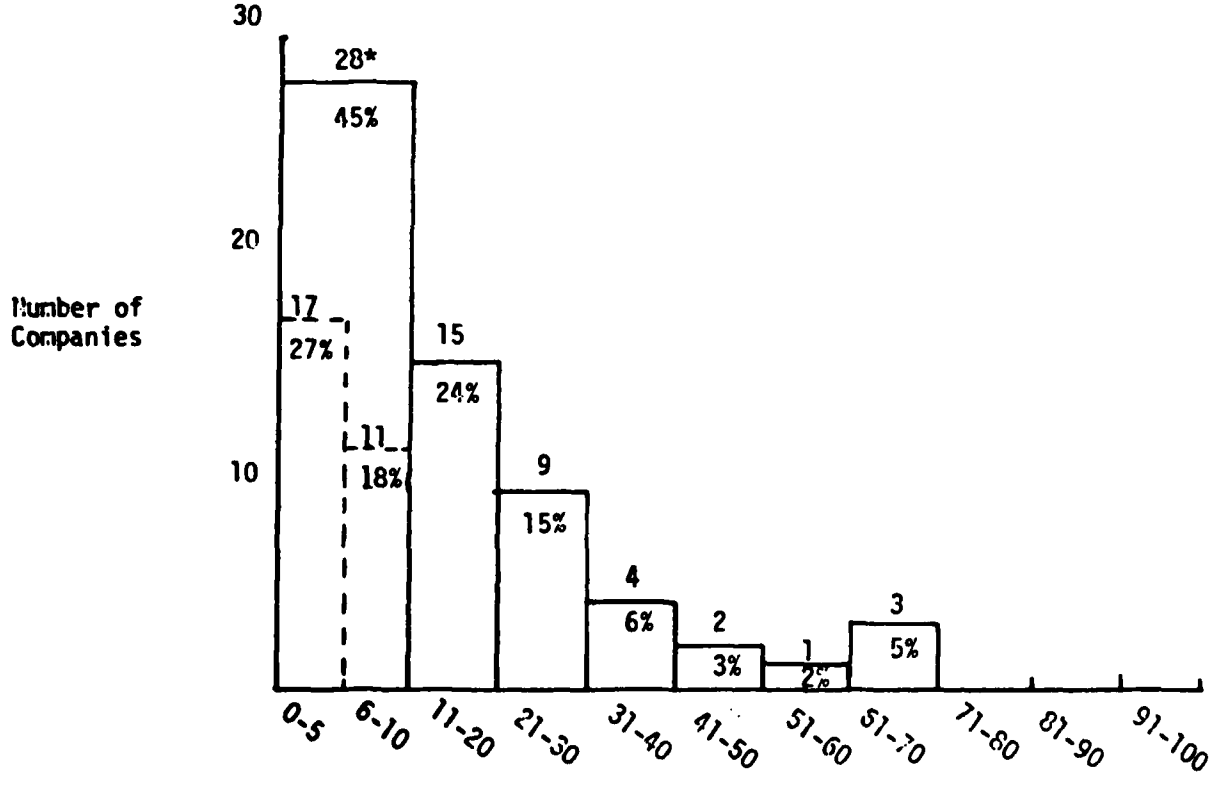
* Number of companies in each cateogry.
** Percentage of total number of companies in each category.

Exhibit 24

PORTABLE COMPRESSOR'S

SMALL METRIC MANUFACTURERS

PERCENTAGE OF TOTAL PRODUCTION IN METRIC

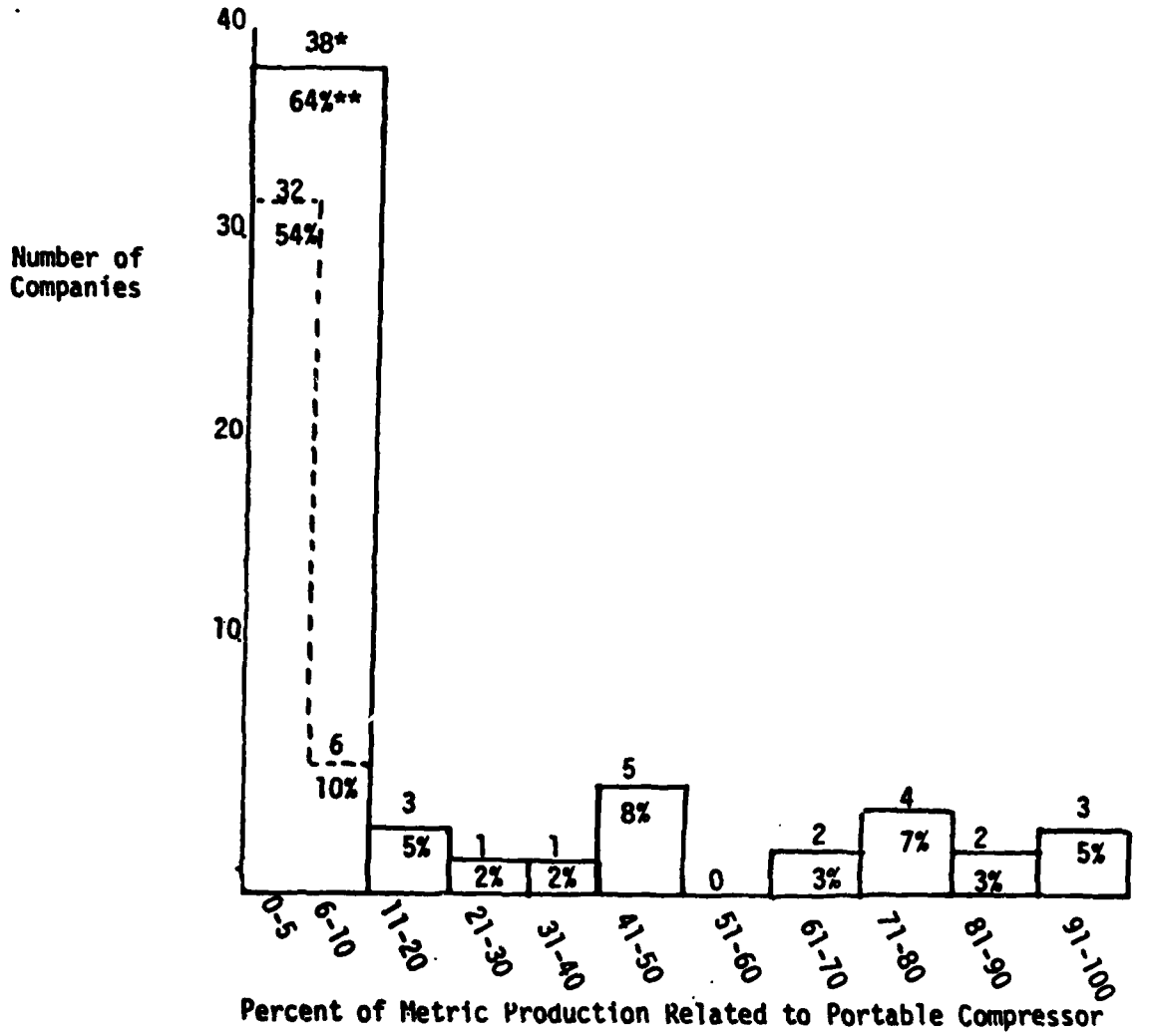


Average = 19%
Median = 15%
Total number of companies = 62

* Number of companies in each category
** Percentage of total number of companies in each category.

Exhibit 25

PORTABLE COMPRESSOR'S
SMALL METRIC MANUFACTURERS
PERCENTAGE OF METRIC PRODUCTION RELATED TO PORTABLE COMPRESSOR



Average = 24%
Median = 5%
Total number of companies = 59

* Number of companies in each category.
** Percentage of total number of companies in each category.

Exhibit 26

PORTABLE COMPRESSOR'S

SMALL METRIC MANUFACTURERS

RELATION OF PERCENTAGE OF METRIC ACCOUNTED FOR BY PORTABLE COMPRESSOR WITH PERCENTAGE OF PRODUCTION IN METRIC

Percent of Total Production in Metric	Percent of Metric Production Related to Portable Compressor 0-24%	25-49%	50-74%	75-100%	Total
0-24%	24 (41%)	2 (3%)	6 (10%)	8 (14%)	40 (68%)
25-49%	11 (19%)	0	1 (2%)	1 (2%)	13 (22%)
50-74%	6 (10%)	0	0	0	6 (10%)
75-100%	0	0	0	0	0
Total	41 (69%)	2 (3%)	7 (12%)	9 (15%)	59 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

To make their metric products, Mocksville's suppliers do not make substantial investments in converting. Four companies spent between $5,000 and $10,000. A third spent nothing. Most investments were made for inspection equipment.

Exhibit 27 shows how the suppliers to Mocksville produce metric parts. A substantial number of suppliers (41%) work in metric and customary to produce metric parts. Almost the same number (42%) continue to work in customary. Only 3% work in metric alone to produce metric products. The pattern does not change when percentage of total production in metric is considered; the percentage of production in metric does not seem to affect the method of metric production. The same number of companies with over 50% production in metric work in customary or customary and metric (see Exhibit 28).

Most of Mocksville's suppliers see no benefits or problems with metric conversion. Suppliers note problems with the time and aggravation involved in converting (even with Mocksville's conversion charts), difficulties of getting metric tooling, initial errors as a result of conversion, and difficulty getting metric raw materials. Some suppliers mentioned benefits from converting such as increasing foreign sales, keeping existing customers' business and getting new domestic customers. Two companies mentioned that there is less competition on metric work since some companies do not work on metric orders.

Summary

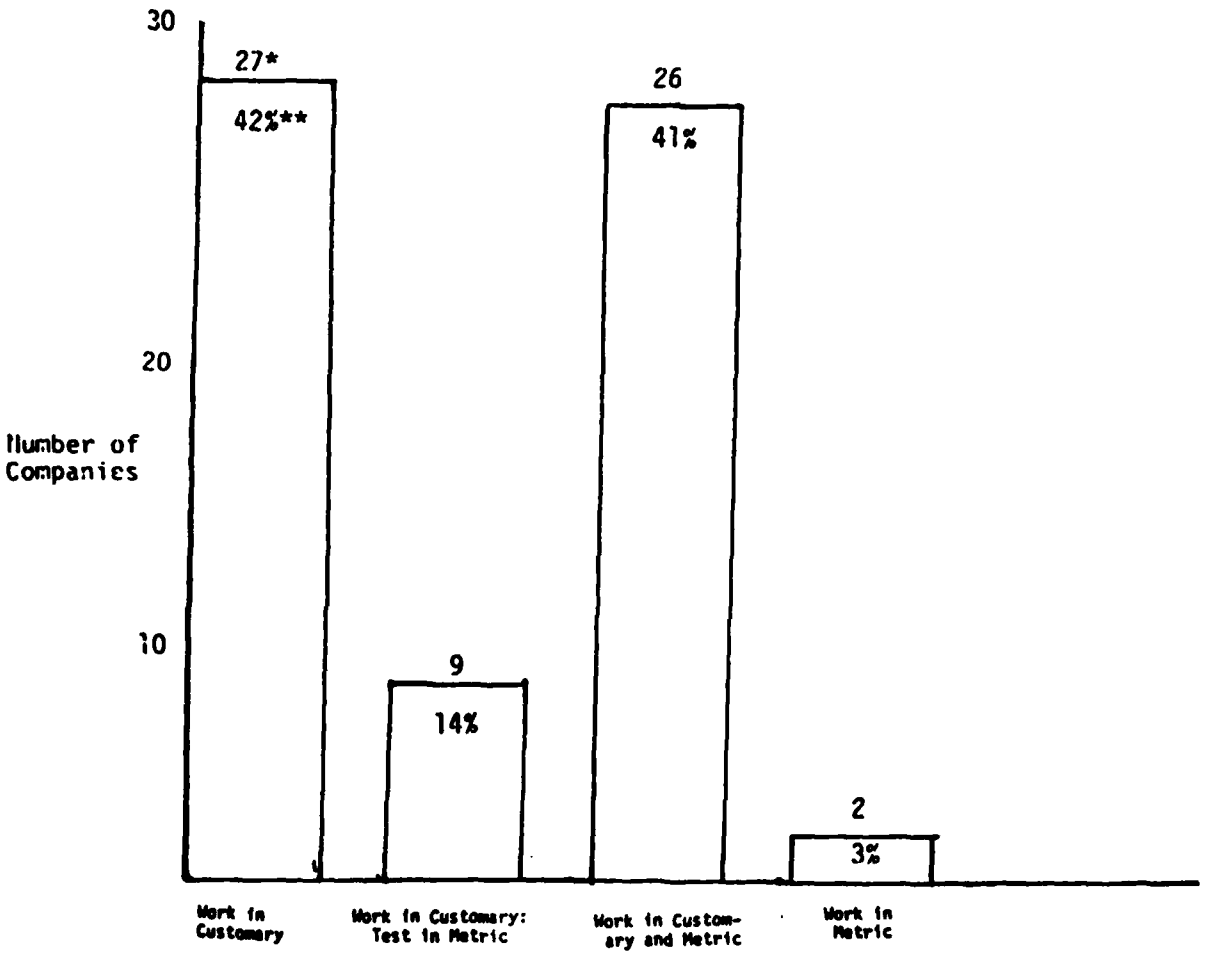
Portable Compressor Division's suppliers support the view that metric conversion has not significantly affected small metric manufacturers. Exhibit 29 summarizes these experiences with metric production. Few have invested over $5,000; most spent less than $1,000. They have had few problems but also few benefits. The only difference between the suppliers' experience and the Mocksville view is a greater tendency for suppliers to do at least a portion of their metric production in metric units.

Exhibit 27

PORTABLE COMPRESSOR'S

SMALL METRIC MANUFACTURERS

METHOD OF METRIC PRODUCTION



Total number of companies = 64

* Number of companies in each category.
** Percentage of total number of companies in each category.

Exhibit 28

PORTABLE COMPRESSOR'S

SMALL METRIC MANUFACTURERS

RELATION OF METHOD OF METRIC PRODUCTION
WITH PERCENTAGE OF PRODUCTION IN METRIC

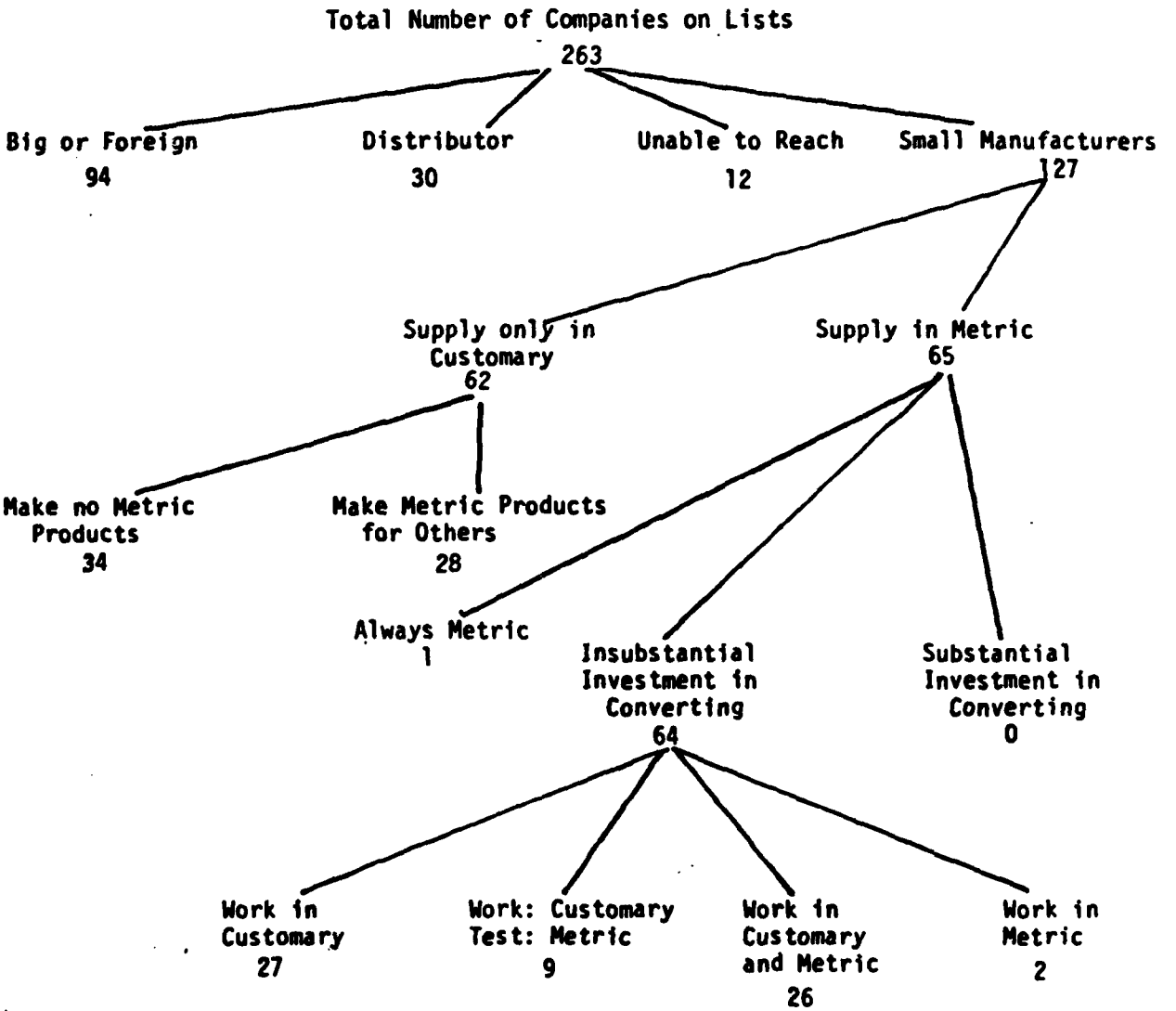
Method of Metric Production

Percent of Total Production in Metric	Work in Customary	Work in Customary: Test in Metric	Work in Customary and Metric	Work in Metric	Total
0-24%	20 (32%)	5 (8%)	17 (27%)	1 (2%)	43 (69%)
25-49%	5 (8%)	3 (5%)	5 (8%)	0	13 (21%)
50-74%	2 (3%)	1 (2%)	2 (3%)	1 (2%)	6 (10%)
75-100%	0	0	0	0	0
Total	27 (44%)	9 (15%)	24 (39%)	2 (3%)	62 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

Exhibit 29

METRIC ACTIVITY IN PORTABLE COMPRESSOR SUPPLIERS



IVA. POWER TOOL SUMMARY

General Finding

Metric fits comfortably into the relations between Ingersoll-Rand's Power Tool Division's Roanoke Facility* and its suppliers and into the operations of the suppliers. Power Tool has converted 15% to 20% of its production to metric. This conversion has resulted in few problems or investments for its suppliers. Half of Power Tool's suppliers do less than 10% of their metric work for Roanoke. Roanoke has not dropped any suppliers because of metric. Suppliers see few problems or benefits resulting from Power Tool's conversion.

The Case Study

The general finding above and the detailed findings below come from a case study of Ingersoll-Rand Power Tool Facility's conversion to metric. The case study looks into how small businesses respond to large corporations' needs. Large corporations' demands often drive small businesses conversion.

Previous research led to hypotheses about the interaction among large and small businesses on metric. The study team investigated these hypotheses through interviews with the appropriate Power Tool departments and contacts with 41 small manufacturers.

Detailed Findings

The detailed findings are:

- Many small manufacturers working for Roanoke produce metric products. Of the 41 contacted, 63% produce metric products for Roanoke. Another 22% produce metric products for other customers but not for Power Tool.
- Half of the small metric manfacturers supplying Roanoke have 45 or fewer employees; the average has 79.
- Portable Compressor's metric suppliers do little of their work in metric. They average 15% of their total production to metric dimensions. Half do 10% or less of their work to metric.

---

*This report covers only the Roanoke Facility of the Power Tool Division. For convenience, the report refers to the facility as Power Tool Facility, Power Tool, or Roanoke.

- Power Tool has not forced its suppliers to make significant investments to produce metric products. Half of Power Tool's metric suppliers do less than 10% of their metric work for Roanoke.
- Suppliers invest very little to convert to metric. Of the 25 suppliers that had converted to metric, 40% said they had spent nothing. The other 60% spent less than $10,000 on tooling and quality control equipment.
- Many of Power Tool's suppliers produce metric products using customary dimensions (48%). The rest work in customary and metric dimensions (28%) only in metric (12%),or in customary while testing in metric (12%).
- Few suppliers report problems or benefits from conversion. Several companies mentioned problems with getting metric supplies.

IVB. POWER TOOL BACKGROUND

What is Power Tool Facility?

Power Tool Division's Roanoke Facility is part of the Professional Tool Group of Ingersoll-Rand Company. Power Tool Facility is a descendant of one of the original companies that combined in the late 19th century to form Ingersoll-Rand. It manufactures air starter motors, winches, drills, and hoists. Air starter motors are used primarily in trucks and off road vehicles where batteries are not suitable. Exhibits 30 and 31 show hoists and starters made by Power Tool.

The Power Tool Facility is located in Roanoke, Virginia. The plant, built in 1968, operates seven days a week, 24 hours a day, producing starters, hoists, winches, and other products. They employ over 500 people to make these products.

The facility is doing well at present. Their starter motors are used on many oil drilling and pumping platforms. Using compressed air instead of an electrical ignition, these motors are more suitable in highly flammable environments. With the boom in the energy industry - especially oil and gas - has come increased demand for Roanoke's air starters.

Metric Conversion at Power Tool Division

Power Tool Facility converted to metric in response to the 1975 Ingersoll-Rand corporate metric conversion program. Power Tool chose to convert only newly designed products. Modifications of older products and continued production of the older products remained in customary. Power Tool Facility has slow turnover in product lines. They are still making products that were originally designed in 1918. The heart of the winch line was designed in the 1930s. Only 10% of their products are new in the last seven years.

As a result of the slow turnover in products at Roanoke, metric has made slow progress in Power Tool's products. Roanoke estimates 15% to 20% of their production is to metric dimensions. Their

EXHIBIT 30

INGERSOLL-RAND AIR CABLE HOISTS

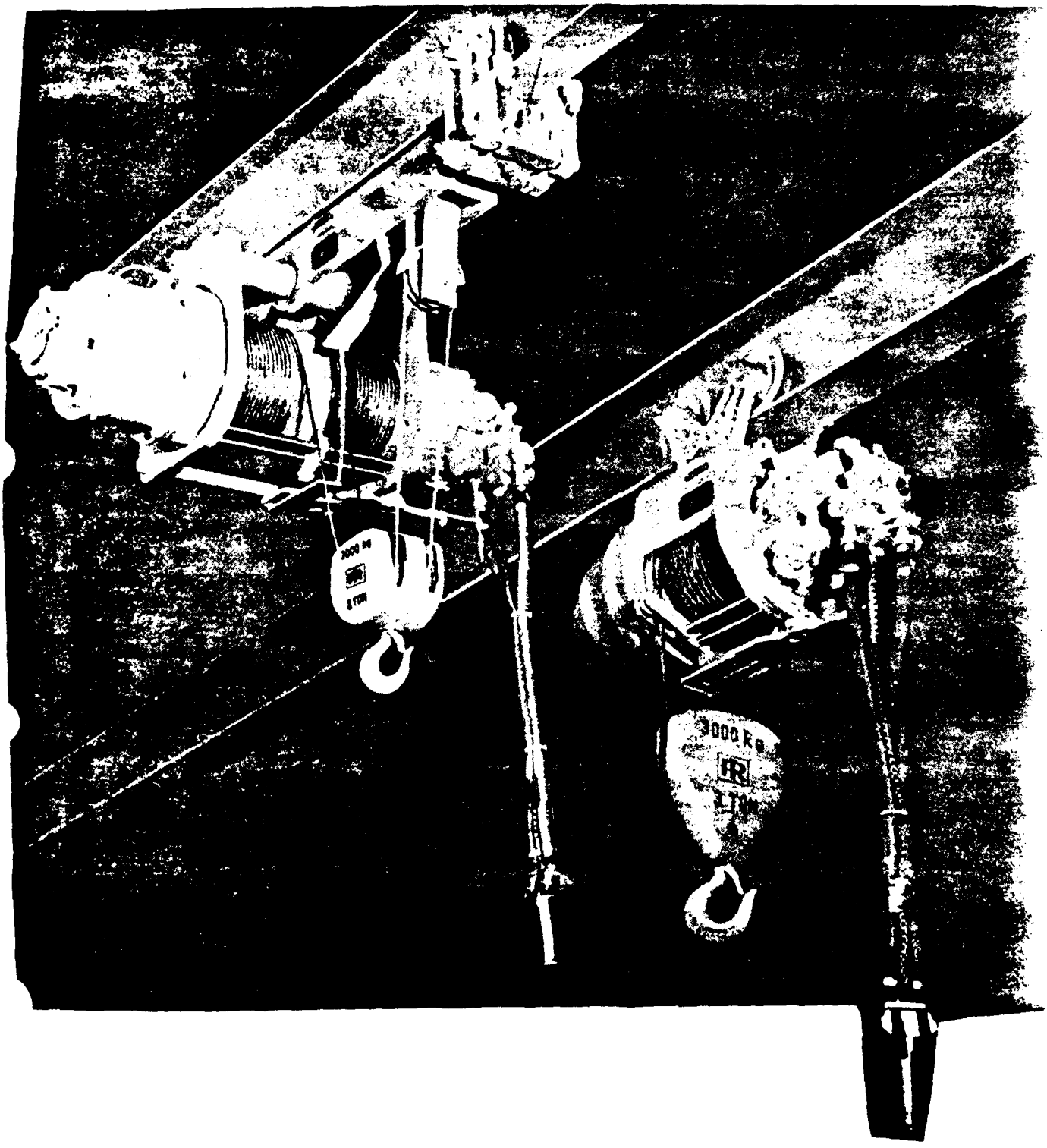
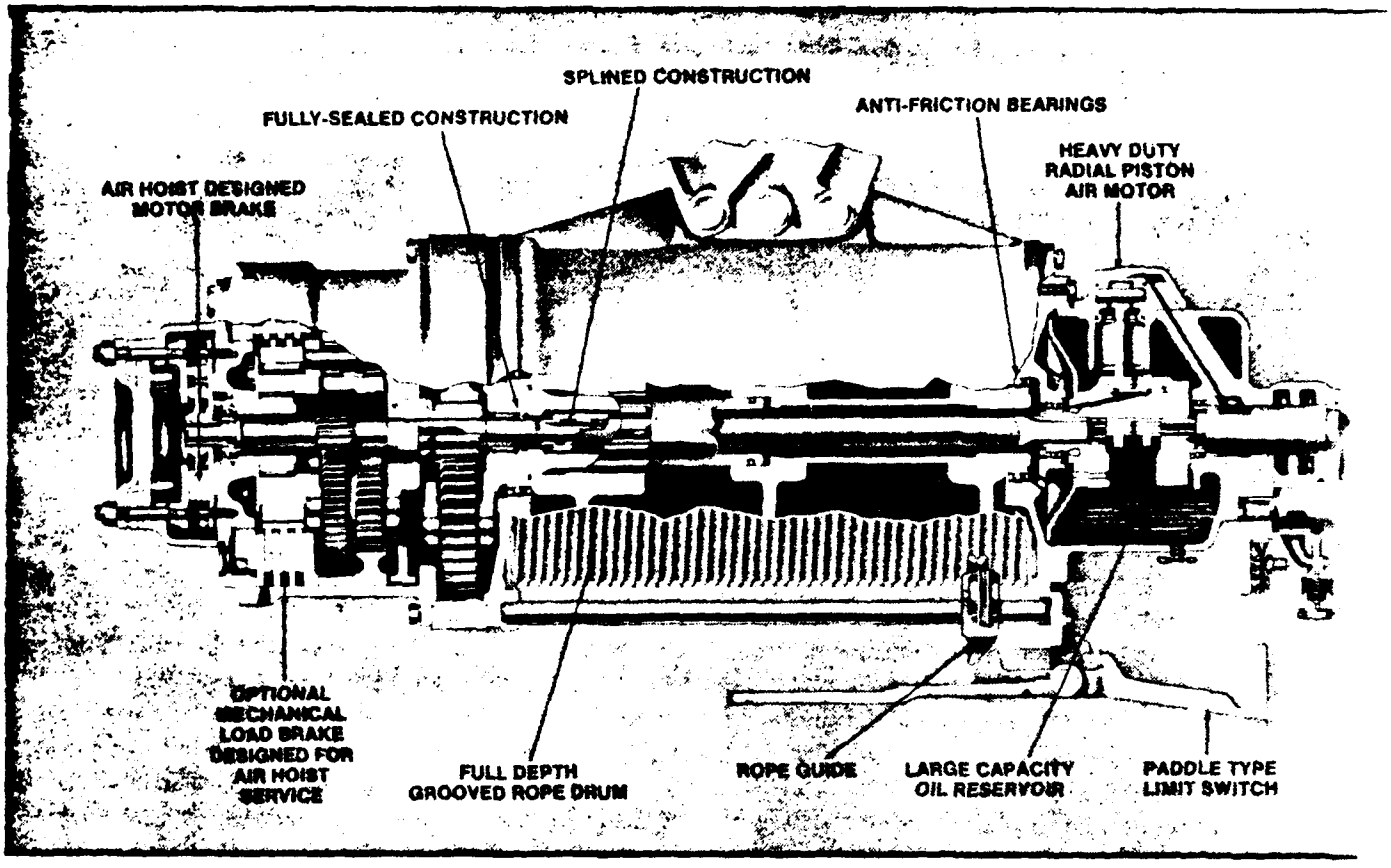


EXHIBIT 30 (continued)

INGERSOLL-RAND AIR CABLE HOISTS



CAPACITIES
¼ to 10 tons
250 to 10,000 Kg

LIFTS
15 to 60 feet
4½ to 18 m

SUSPENSIONS
Push, lug, hand chain operated and motorized trolleys.

DUAL BRAKES
Motor brake and mechanical load brake option.

CONTROL
Pendent
Pull Chain
Remote

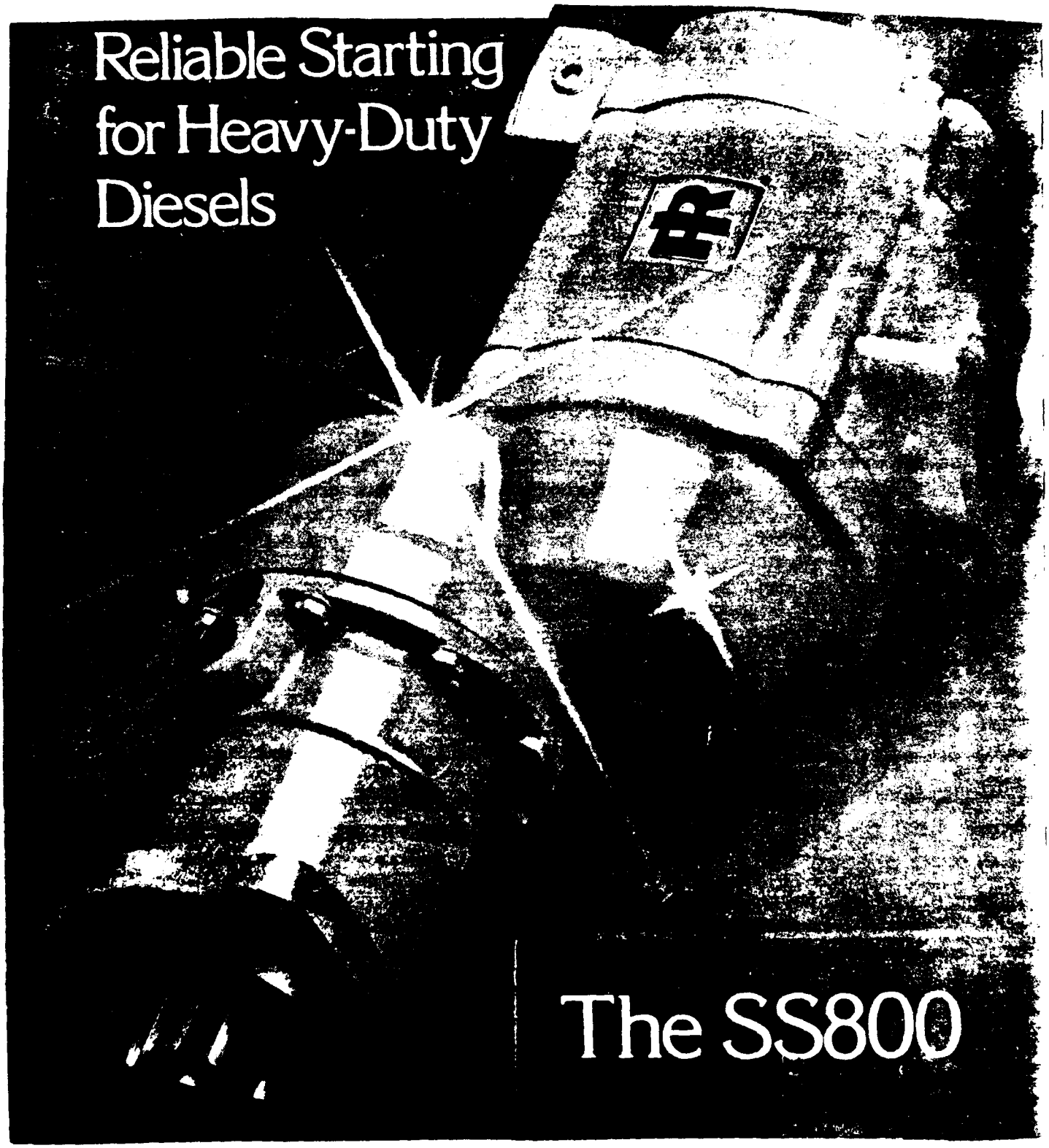
LOW HEADROOM
1 to 5 ton (1000 to 5000 Kg) capacities. Two part double reeving is standard

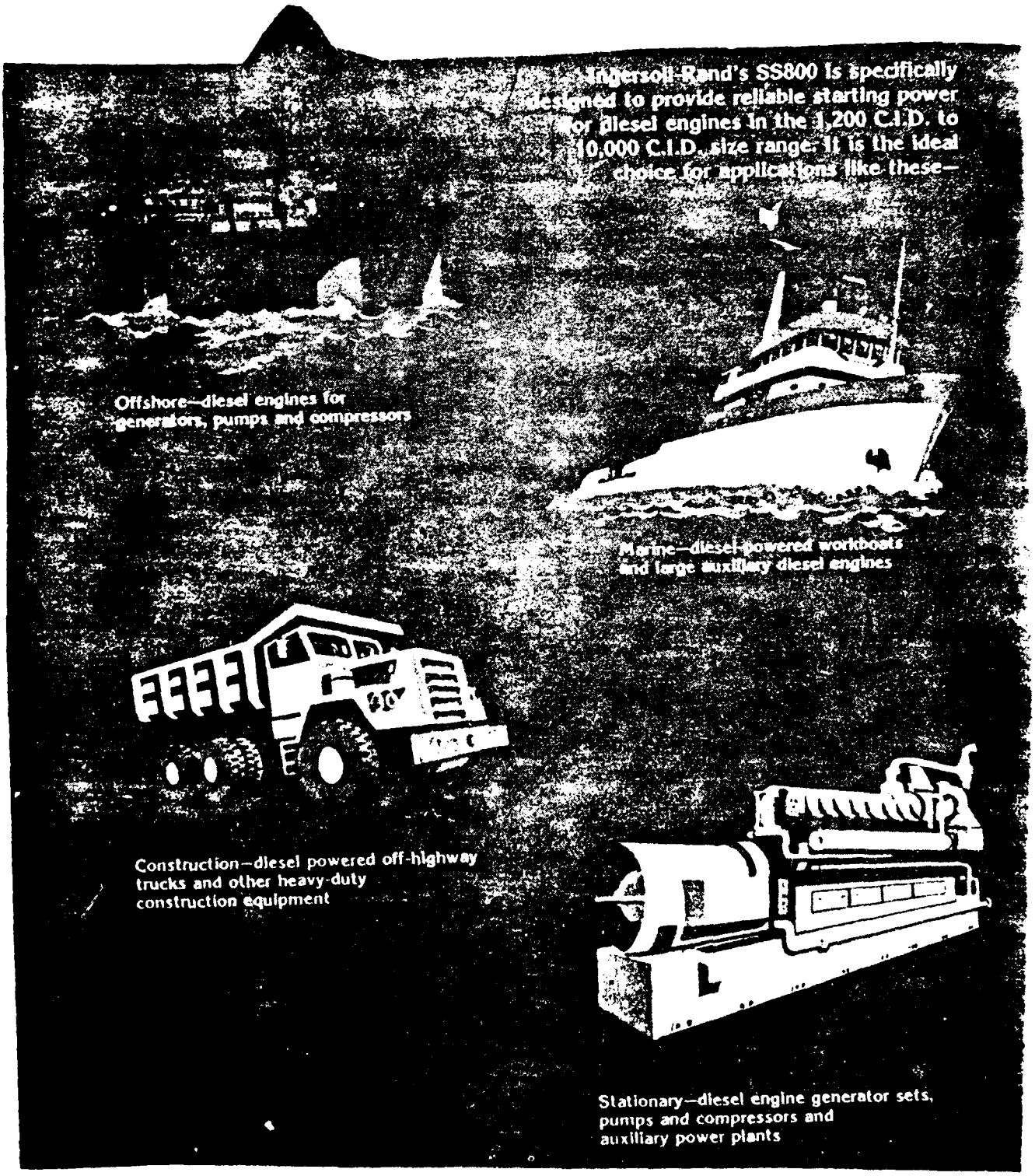
SPARK RESISTANT
Available in all capacities

TRACTORS
Air motorized tractors that pull hoist along a monorail system

EXHIBIT 31

AN INGERSOLL-RAND AIR STARTER




Ingersoll-Rand's SS800 is specifically designed to provide reliable starting power for diesel engines in the 1,200 C.I.D. to 10,000 C.I.D. size range. It is the ideal choice for applications like these—
Offshore—diesel engines for generators, pumps and compressors
Marine—diesel-powered workboats and large auxiliary diesel engines
Construction—diesel powered off-highway trucks and other heavy-duty construction equipment
Stationary—diesel engine generator sets, pumps and compressors and auxiliary power plants

initial involvement in metric production came with a new air starter motor designed in 1978. Their most recent metric product is an air winch (see Exhibit 32). Only recently has this metric winch become a good seller. The slow introduction of the metric air winch had nothing to do with its metric dimensions; it was a case of customers preferring a proven product over a new product.

To produce their metric products, Power Tool works with metric-only drawings. The division chose not to use dual dimensioned drawings because it would (a) consume too much engineering time, and (b) increase the potential for error. Power Tool knows many of its suppliers convert their metric drawings to customary units to produce metric products. They prefer to have suppliers responsible for any errors in conversion.

What Follows

The next two sections describe Power Tool's conversion from two perspectives. First, the report describes the effect of conversion on relations among Power Tool and its suppliers. The other section describes the effects of Power Tool's conversion on its suppliers.

EXHIBIT 32

INGERSOLL-RAND AIR WINCHES

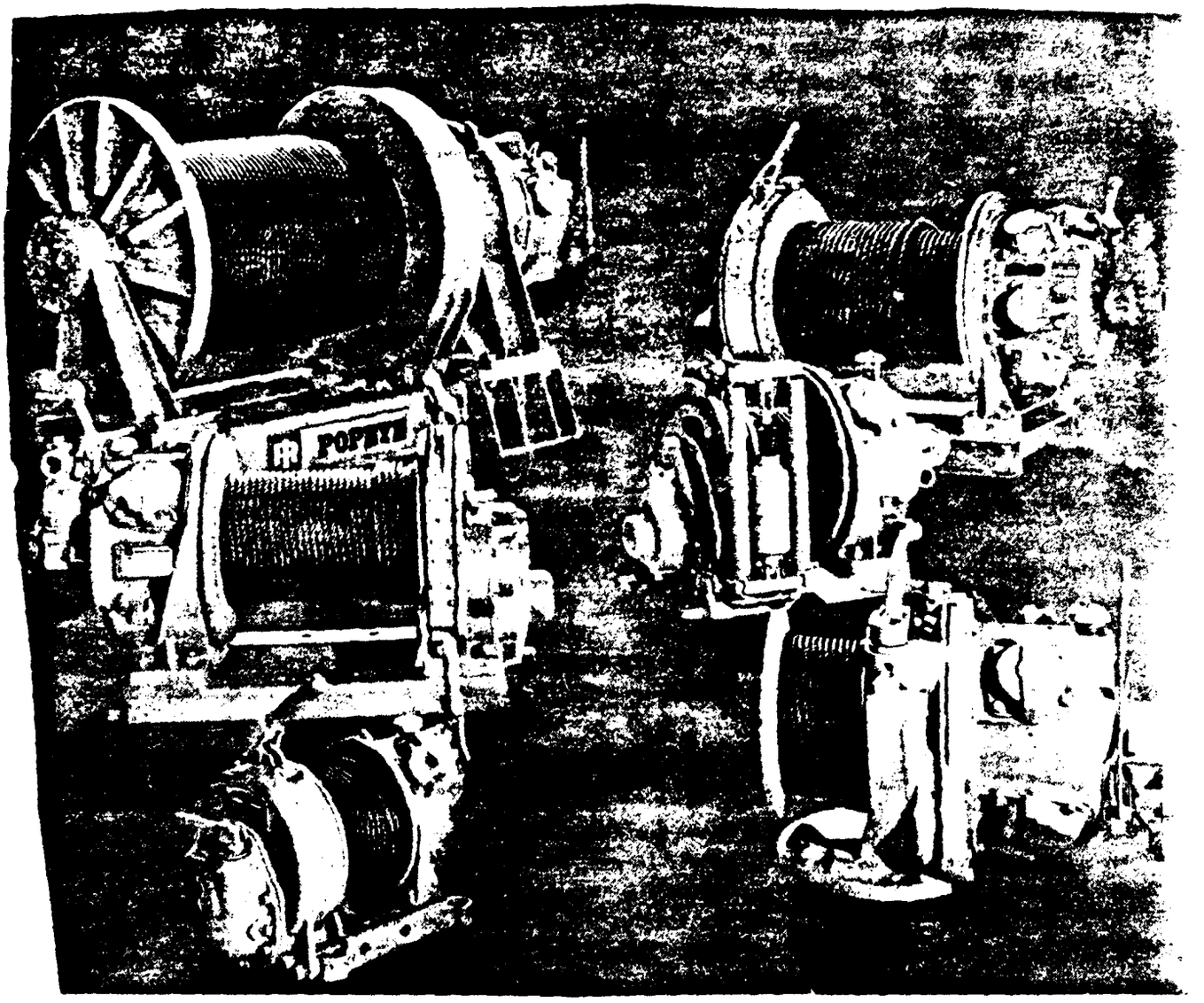


EXHIBIT 32 (continued)

INGERSOLL-RAND AIR WINCHES

Ingersoll-Rand

AIR WINCHES

Check these features and benefits...

1. **ENCLOSED CONSTRUCTION** excludes dirt and dust, seals in oil and grease assuring complete lubrication of all moving parts.

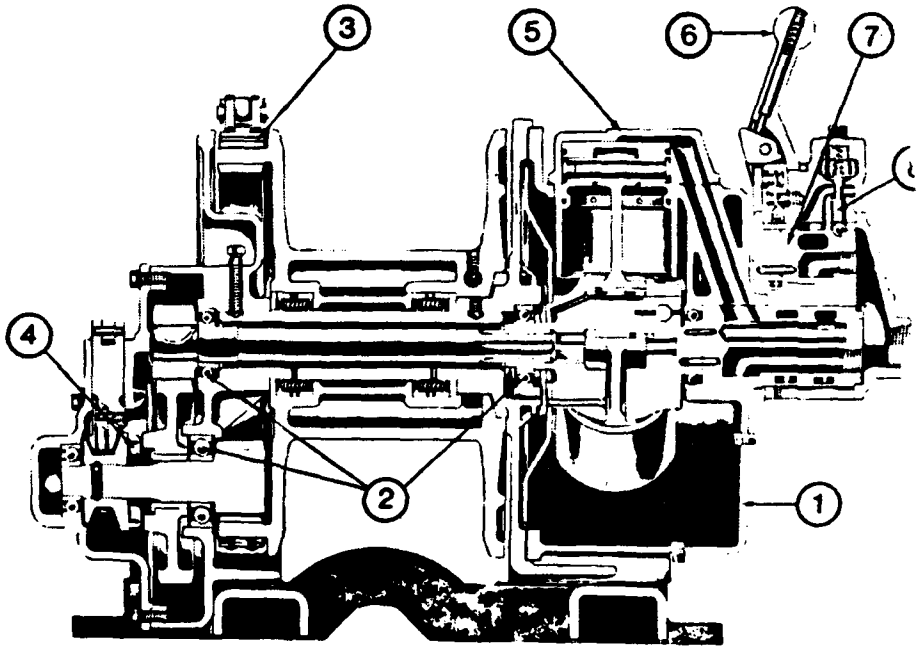
2. **BALL AND ROLLER BEARINGS** reduce friction; Ingersoll-Rand Air Winches deliver maximum power to the job.

3. **RELIABLE BAND TYPE BRAKE** for holding rated load.

4. **POSITIVE JAW TYPE CLUTCH** permits free wheeling of the rope drum for unwinding the wire rope by hand.

5. **POWERFUL RADIAL PISTON MOTOR** gives positive starting with precise control.

6. **SELF-CLOSING THROTTLE** shuts off automatically when released, gives well graduated control for spotting loads.



7. **REVERSIBLE MOTOR** permits full control of load by the throttle when lifting, lowering and pulling.

8. **POPPET TYPE VALVE** eliminates air leakage when Winch is idle.

IVC. METRIC CONVERSION AND POWER TOOL'S RELATIONS WITH SUPPLIERS

Introduction

The case study of small business-large business interaction on metric conversion covers the effects of metric conversion on the way the large company relates to its suppliers as well as the effects of conversion on small business suppliers and customers. Relations with suppliers refer to:

- Involvement of suppliers in design decisions;
- Effect on design of customer and service organization considerations;
- Effect on design and production of supplier capabilities;
- Interaction and the relative importance of different divisions dealing with small suppliers;
- Primary considerations for each department in its relations with suppliers.

To find how metric conversion affected the way Power Tool deals with its suppliers, the team first developed an overview of the way a product normally is designed, produced, and serviced. With that background, the team looked for changes resulting from conversion.

Metric fits easily into Power Tool's established relations with suppliers. This section describes the stages of the product lifecycle at Power Tool and how metric fits into relations with suppliers at each stage.

Suppliers and the Power Tool Product Lifecycle

Suppliers are involved in many phases of the design, production, and servicing of Roanoke's products. However, different steps in the movement from concept to repair involve different Power Tool departments, different types of suppliers, and different considerations dominating relations between Power Tool and the outside supplier. These differences are important for understanding how metric conversion fit into Power Tool's relations with its suppliers.

Four stages in the movement from concept to repair involve suppliers:

- Prototypes - To prove a concept and improve design, Power Tool's engineering department builds prototypes of final

products. Some parts must be supplied by outside suppliers for these prototypes.

- Parts for Production - Outside suppliers make parts for Power Tool Facility's finished product. Some parts are standard items such as nuts and bolts; others are unique or custom parts designed for that product, such as metal brackets for holding equipment. Some suppliers do only one or two operations to a part for Roanoke; these are subcontractors.
- Production Equipment - To make a product, Roanoke may need new machines or new capabilities on existing machines. Power Tool may purchase these machines or capabilities from outside suppliers.
- Product Service - After a product leaves Roanoke it may need repair, spare parts, or modification. Power Tool may provide the parts or modification. Most customers service their own products.

The departments in Power Tool Facility involved in these different stages of the product lifecycle include:*

- Engineering - produces the drawings for new products and builds prototypes of new products. They have their own purchasing agent for buying prototype parts.
- Industrial Engineering - is responsible for preproduction runs to test the manufacturing process. They also identify the need for new production equipment and monitor the quality of suppliers' parts.
- Manufacturing - produces the products that come from the Roanoke plant.
- Purchasing - buys parts and production equipment for making the Power Tool's products. They have the most involvement with outside suppliers.

The following sections describe how metric conversion has fit into relations among these departments and their suppliers.

*These brief descriptions only refer to those activities of these departments of direct relevance to supplier relations.

Prototypes

Engineering designs new products and makes prototypes. Once an initial design is accepted, a prototype is made to test the concept. Following an initial prototype, Engineering redesigns the product for appearance and cost and makes additional prototypes. Parts going into the prototype are purchased from outside suppliers.
are purchased from outside suppliers.

Normally, Engineering produces less than 50 prototypes for a product. Thus Power Tool Engineering department purchases small orders from outside suppliers. Engineering has its own purchasing agent to work with prototype suppliers in order to be sure to get their small orders taken care of in time. Speed is critical to the development of prototypes. Engineering cannot afford to wait for parts. The need for quick delivery and the small orders means Engineering often works with local machine shops. In some cases, the engineering buyer pays a premium to get a part in time to meet an engineering deadline.

Metric has had little lasting impact on the purchasing of prototypes. Most of the engineers working on metric products quickly get used to working in metric. With suppliers, the engineering buyer took great care at first to sit down, go over the parts, and point out their metric aspects. He knew suppliers would produce the metric parts using customary dimensions so he closely monitored their conversions. He felt he could afford to spend the time with the suppliers because it would prevent mistakes that would interfere with meeting the engineering schedule. After the first few metric parts, prototype suppliers had little difficulty making metric orders.

Engineering tries to use metric sizes that are similar to customary sizes - such as using 12 millimeter bolts which are quite similar to half-inch bolts. If a metric part is unavailable, Engineering may use the closest customary size and machine it to the proper metric size. For some parts, such as gears, they have had difficulty getting metric sizes at acceptable prices. In these cases they use customary parts.

Initially, Engineering was concerned about the availability of metric parts. They soon found they could get metric parts if they wanted to pay a premium. In the three years Power Tool has been working in metric, the premium for most metric parts has disappeared.

Parts for Production

Following the development of a cost and appearance prototype, Industrial Engineering makes a pre-production run to test the manufacturing process for the new product. A pre-production run produces several hundred products. Industrial Engineering selects suppliers for production parts and orders enough parts for the pre-production runs. Following the pre-production run, Purchasing has the major responsibility for dealing with outside suppliers. Purchasing is usually involved in Industrial Engineering's selection of suppliers and often uses the suppliers selected by Industrial Engineering. Industrial Engineering also assures that the suppliers' parts meet engineering specifications by randomly checking suppliers' shipments.

Power Tool Facility uses three types of parts in its production:

- Off the shelf items - such as nuts, bolts, and other standard hardware items.
- Proprietary parts - parts designed and manufactured by other companies but used as part of Power Tool's product.
- In-house design parts - designed by Power Tool solely for use on their products. Suppliers use Power Tool's drawings to produce the products.

-- In a number of cases, Roanoke may use an outside supplier to do only one or two operations - such as milling, grinding, turning, etc. - on a part. These suppliers are called subcontractors. Power Tool distinguishes between large subcontractors and small subcontractors (the latter being those working on 25 or fewer pieces). Less than 10% of subcontract work is done by small subcontractors.

Power Tool Facility prefers to make its own parts where feasible. Traditionally they have not used many outside suppliers, making up 90% of their own parts. By making their own parts, Roanoke can keep control over costs, quality, and delivery - key factors in producing a competitive product. However, as business has grown, Power Tool has decided to buy as well as make. Power Tool estimates that 30% of their parts are now made by outside suppliers.

Metric conversion has not affected relations with suppliers of off the shelf, proprietary, and in-house designed parts. Using three to six bids per part, Industrial Engineering and Purchasing select the supplier that has lowest cost, best quality, and can deliver on

time. Their suppliers have not changed as a result of metric. Standard parts such as nuts and bolts are readily available in metric; in some cases they deal with foreign manufacturers of these parts because they can set up long-term supply contracts. With proprietary parts, Power Tool takes what the designer and manufacturer offer. In most cases proprietary parts are designed in customary units. Power Tool has most control over those parts it designs. Suppliers of in-house design parts have readily accomodated to Power Tool's demands for metric products.

In subcontracting on metric parts, Power Tool will often give small subcontractors the tools to perform the operations on their parts. Power Tool uses small subcontractors to handle overflows of its plant capacity. Rather than pay the costs for a duplicate set of tools, gauges, and fixtures, Roanoke lends the small subcontractor the tools. This is done on customary and metric parts. Metric has not led to an increase or decrease in this practice.

Power Tool did have one instance where a subcontractor made an incorrect conversion on a part and produced unacceptable parts. Since the error in conversion was the fault of the subcontractor, the subcontractor paid for the mistake. This is the only instance of metric causing any problems in the purchase of parts for production.

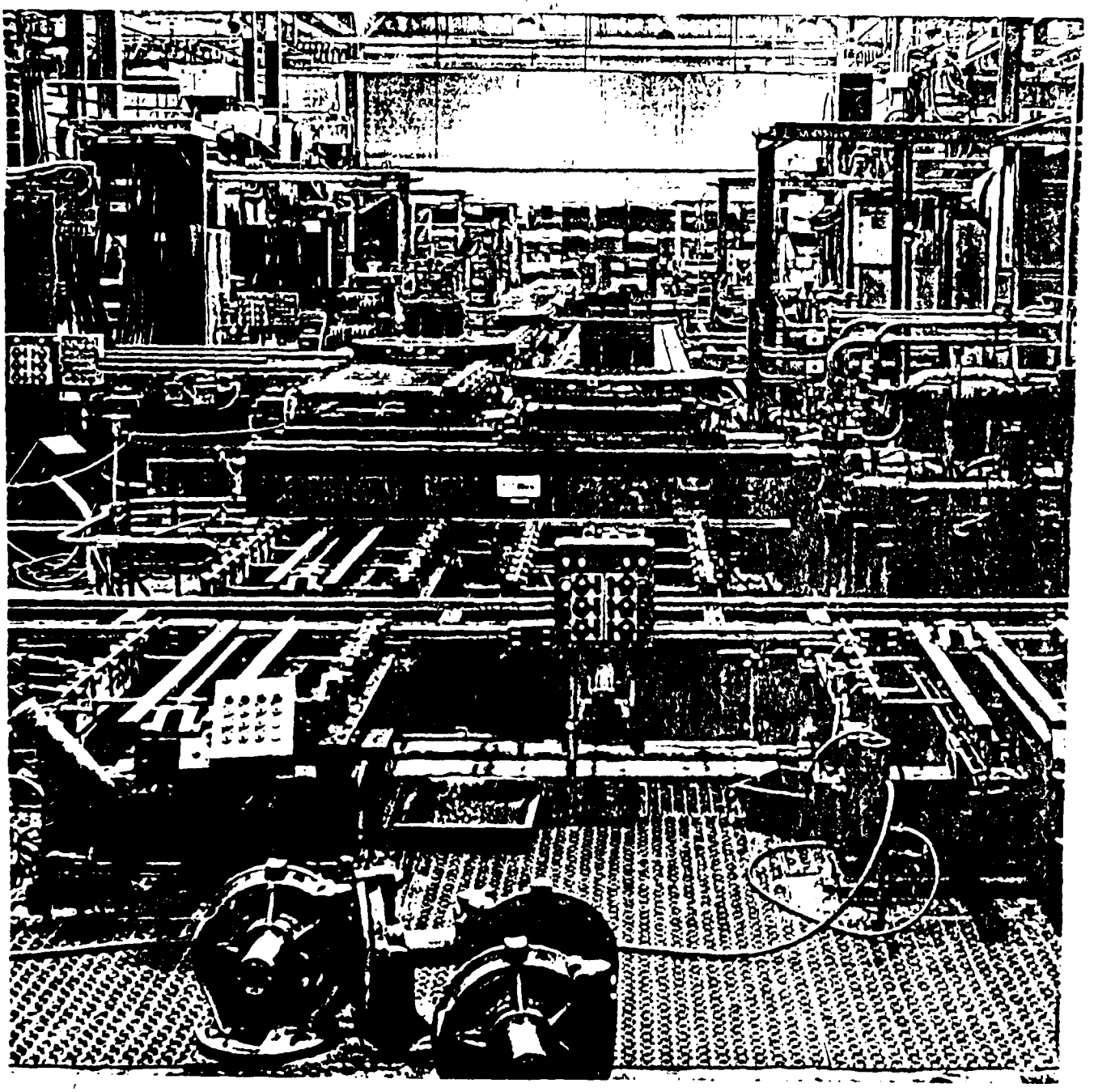
Production Equipment

Much of the production equipment at Power Tool Facility has Computer Numerical Control [CNC] (See Exhibit 33). With CNC it is very easy to switch from one measurement system to another. As Industrial Engineering buys new production equipment, it purchases machines that are capable of working in customary and metric. When Power Tool first converted to metric, they invested over $15,000 -- half on dials for machines, and half for digital readouts. They did not make a larger investment because operators do most of the measuring during production with hand-held micrometers or other measuring instruments.

Power Tool has not invested in metric quality control equipment for two reasons. First, most of the gauging for its products are "go/no-go" gauges. These are designed for each individual part to quickly indicate whether the part does or does not meet specifications. As long as the part is in the "go" range it is accepted.

EXHIBIT 33

POWER TOOL'S COMPUTER CONTROLLED MANUFACTURING



Second, quality control is the responsibility of the individual machine operator. The operators are expected to have their own quality control equipment as part of their personal tool kit. When the company converted to metric, they held a discount sale of metric measuring devices in conjunction with a measuring equipment producer. Employees spent an average of $250 on metric measuring equipment.

Product Service

Power Tool Facility does very little repair work on its products. Most repair work is handled by customers or other service companies. Power Tool only sees its old product when a customer wants to recondition, modify, or upgrade a product. The rebuild orders account for less than 2% of Power Tool's total business. Power Tool does produce Repair and Rebuild Kits for their products (See Exhibit 34).

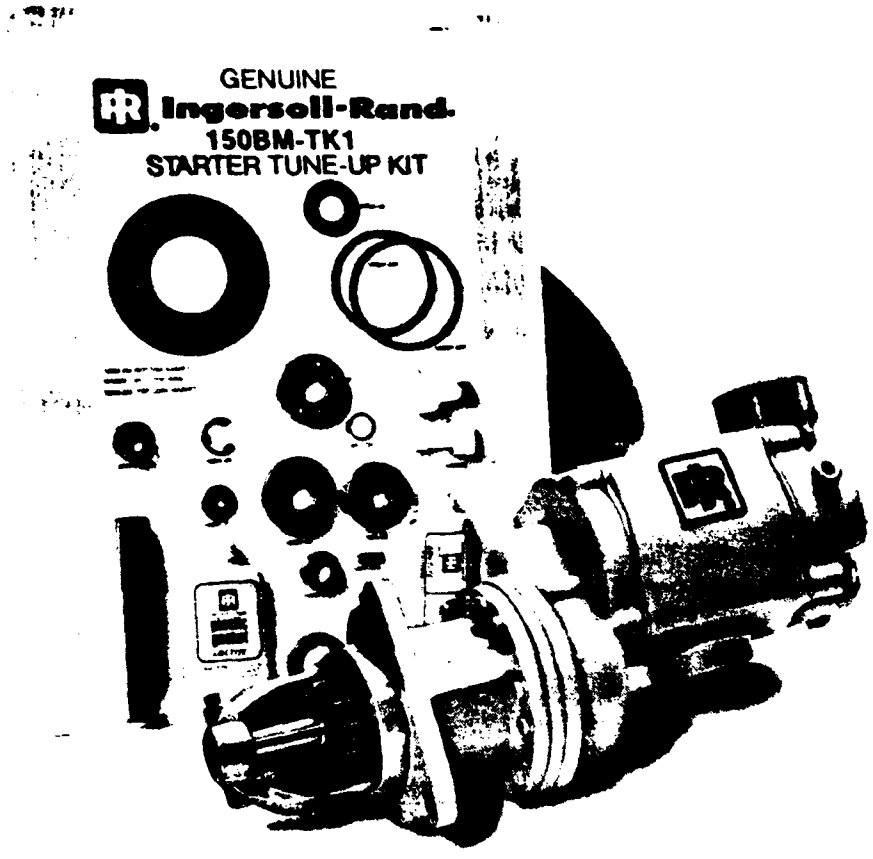
Power Tool has had little experience with rebuilding or repair work on their metric products. They have been producing metric products for less than 5 years; they have not had many requests for repair or rebuilding on their metric starters and air winches. They have not heard of any problems with servicing metric products from their customers.

Summary

Metric conversion fit comfortably into Power Tool's relations with its suppliers all along the product lifecycle. Any problems or concerns were transitory as Power Tool and its suppliers rapidly became accustomed to working with metric products. The following section describes the effects of Power Tool's conversion on its suppliers.

EXHBIT 34

AN INGERSOLL-RAND AIR STARTER TUNE-UP KIT



Give your starters a fresh start

We've made it easy and economical to perform regular preventive maintenance on your air starters. Each of our tune-up kits contains all the parts you need to keep your starters operating at peak efficiency. Parts are fully protected until they're ready to be used. And there's a schematic on the back of each package that shows where and how each part is used. Best of all, you pay less for these kits than you would for the parts alone.

Order your tune-up kit from your conveniently located I-R Distributor. And put new life into your starters.

IVD. EFFECTS OF POWER TOOL'S CONVERSION ON ITS SUPPLIERS

Introduction

How has Power Tool's conversion to metric affected its suppliers? The previous section described the effects of metric conversion on the relations among Power Tool Division and its outside suppliers. This section describes the effects of Power Tool's conversion on its small business suppliers - the costs, the benefits, and the problems or opportunities. Before describing the suppliers' views of the effects of Power Tool's conversion, the section discusses the view of Power Tool Facility of its effects on its suppliers.

Power Tool's View of the Effects of Conversion on Suppliers

Power Tool feels its conversion has no effect on its suppliers. The size of Power Tool's orders are relatively small - even for a full-scale production run. They do not have the "economic clout" to dictate to any of their suppliers how to produce their products. Second, they know many of their suppliers convert Roanoke's metric drawings to customary to produce the products. They do not care how the supplier makes the part as long as it meets Power Tool's specifications.

Suppliers' Views on the Effects of Power Tool's Conversion

Power Tool's suppliers confirm Roanoke's view of the impact of its conversion - few problems, few costs, few benefits, and continued production using customary units. These observations are based on contacts with 26 small manufacturers (independent businesses with less than 500 employees) of metric products for Power Tool. One of these companies had always produced metric products. These 26 companies came from a more extensive list of companies including 19 big (500+ employees) or foreign companies, 3 distributors, 6 small manufacturers working only in customary, and 9 small manufacturers producing metric products for companies other than Power Tool.

The companies producing metric products for Power Tool range from a four-employee machine shop to a 400-employee foundry. The

average small metric supplier to Power Tool has 79 employees; half the companies have 45 employees or fewer (See Exhibit 35). Most of the companies are located in Virginia or North Carolina; others are in Ohio, Pennsylvania, New York, South Carolina, and Maryland. Of the 25 companies which converted, 6 make castings. The remaining 19 produce machined parts, forgings, gears, and other parts.

Suppliers making metric parts for Power Tool do a small portion of their production to metric dimensions. Half of the firms produce 10% or fewer of their products to metric dimensions; the average is 15% (See Exhibit 36). None of Power Tool's metric suppliers make over 35% of their products to metric dimensions.

Power Tool is responsible for a small part of its suppliers' metric activity. Half the suppliers do 10% or less of their metric work for Power Tool (See Exhibit 37). Relating the percentage of metric work accounted for by Power Tool with the percentage of total production in metric (Exhibit 38) shows the limited effect of Power Tool on its metric suppliers more clearly. Of the five firms for whom Power Tool accounts for over 75% of metric production, four devote less than 25% of their production to metric. Of these four, three devote 5% or less of their production to metric; the other one devotes 10%.

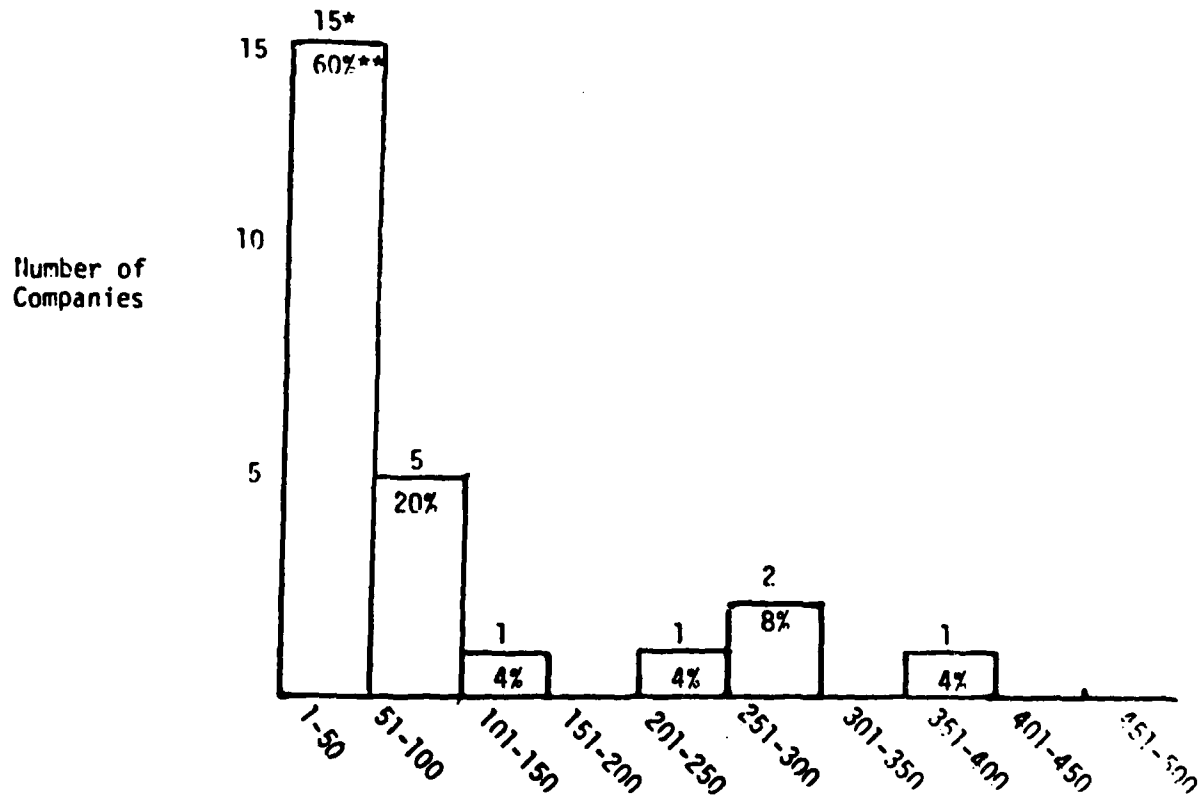
Suppliers of metric parts to Power Tool also supply metric parts to other customers. These include IBM, Warner & Swazey, Firestone, Philip Morris, Deico Machine, textile machinery manufacturers, automotive companies, steel companies, and foreign customers (overseas and at domestic U.S. plants).

Power Tool's metric suppliers do not make substantial investments to produce metric products. None spent over $10,000. Ten spent nothing. Most investments made were for inspection equipment, taps, dies, and digital readouts.

Exhibit 39 shows how the suppliers to Power Tool produce metric parts. A significant portion of the 25 suppliers (40%) work in metric or work in metric and customary to produce metric parts. However, 48% continue to work in customary. The pattern does not change when percentage of total production in metric is considered; three of the seven firms doing over 25% of their work in metric continue to work in customary. Another three work in customary and metric (See Exhibit 40). Both firms working in only metric devote less than 25% of their production to metric.

Exhibit 35

POWER TOOL'S
SMALL METRIC MANUFACTURERS
NUMBER OF EMPLOYEES



Average = 79
Median = 45
Total number of companies = 25

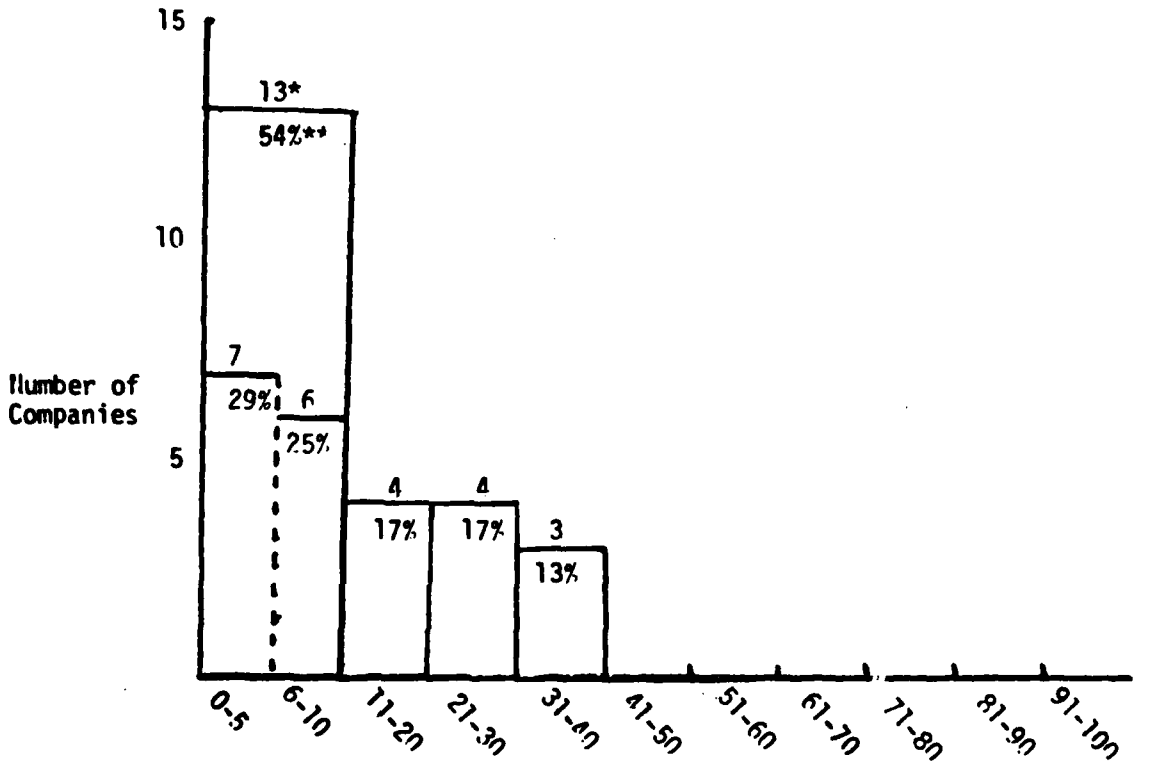
*Number of companies in each category.
**Percentage of total number of companies in each category.

Exhibit 36

POWER TOOLS

SMALL METRIC MANUFACTURERS

PERCENTAGE OF TOTAL PRODUCTION IN METRIC



Average = 15%
Median = 10%
Total number of companies = 24

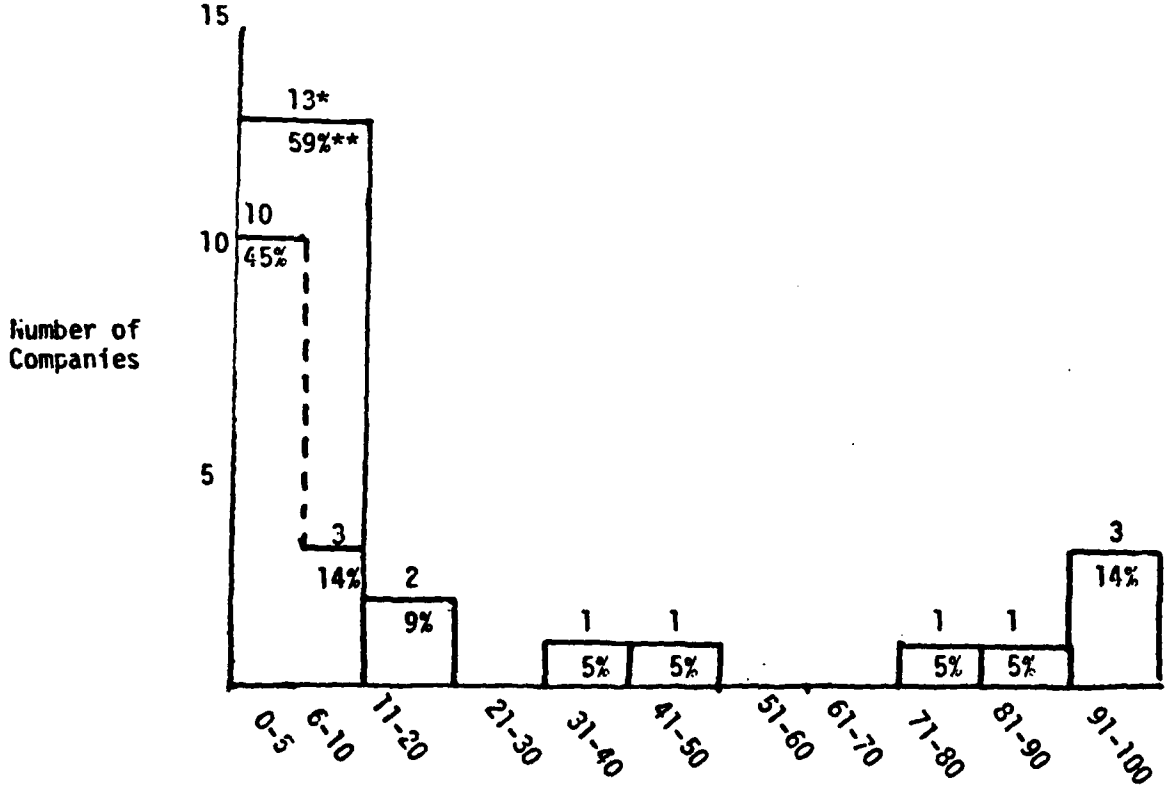
*Number of companies in each category.
**Percentage of total number of companies in each category.

Exhibit 37

POWER TOOL'S

SMALL METRIC MANUFACTURERS

PERCENTAGE OF METRIC PRODUCTION RELATED TO POWER TOOL



Average = 29%
Median = 10%
Total number of companies = 22

*Number of companies in each category.
**Percentage of total number of companies in each category.

Exhibit 38

SMALL METRIC MANUFACTURERS:

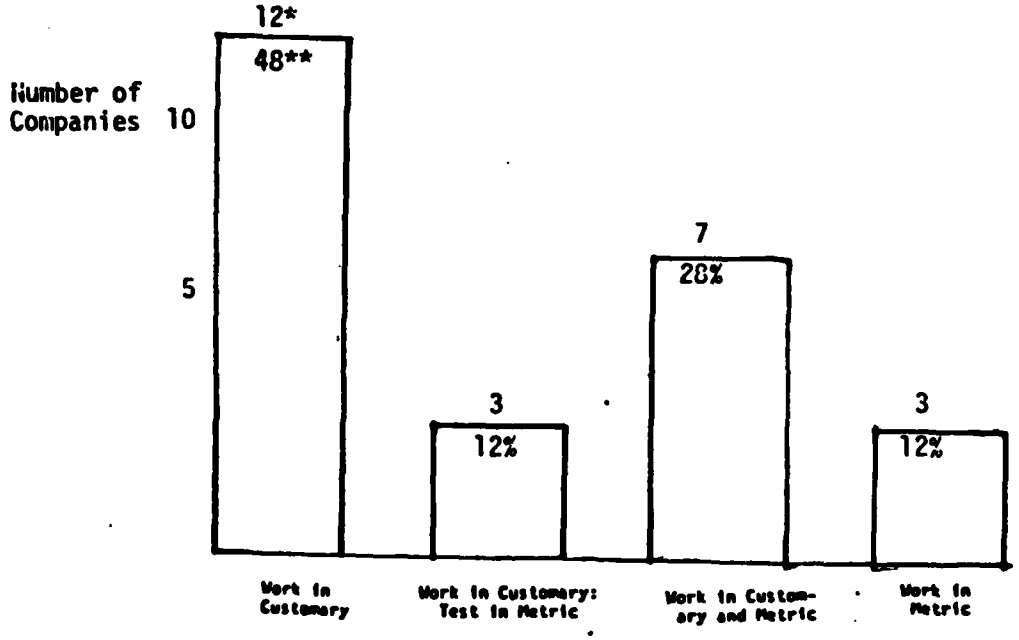
RELATION OF PERCENTAGE OF METRIC ACCOUNTED FOR BY POWER TOOL WITH PERCENTAGE OF PRODUCTION IN METRIC

Percent of Metric Production Accounted for by Power Tool

Percent of Total Production in Metric	0-24%	25%-49%	50-74%	75-100%	Total
0-24%	10 (45%)	0 (0%)	1 (5%)	4 (18%)	15 (68%)
25-49%	5 (23%)	1 (5%)	0 (0%)	1 (5%)	7 (32%)
50-74%	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
75-100%	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	15 (68%)	1 (5%)	1 (5%)	5 (23%)	22 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

Exhibit 39
POWER TOOL'S
SMALL METRIC MANUFACTURERS
METHOD OF METRIC PRODUCTION



Total number of companies = 25

*Number of companies in each category.
**Percentage of total number of companies in each category.

Exhibit 40

POWER TOOL'S SMALL METRIC MANUFACTURERS:

RELATION OF PERCENTAGE OF TOTAL PRODUCTION IN METRIC WITH METHOD USED IN PRODUCTION OF METRIC PRODUCTS

METHOD

Percent of Metric Production	Work in Customary	Work in Customary: Test in Metric	Work in Customary and Metric	Work in Metric	Total
0-24%	9 (38%)	2 (8%)	4 (17%)	2 (S%)	17 (71%)
25-49%	3 (13%)	1 (4%)	3 (13%)	0 (0%)	7 (29%)
50-74%	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
75-100%	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	12 (50%)	3 (13%)	7 (29%)	2 (8%)	24 (100%)

Note: As a result of routine rounding, column and row percentages may not agree with the sums of cell percentages.

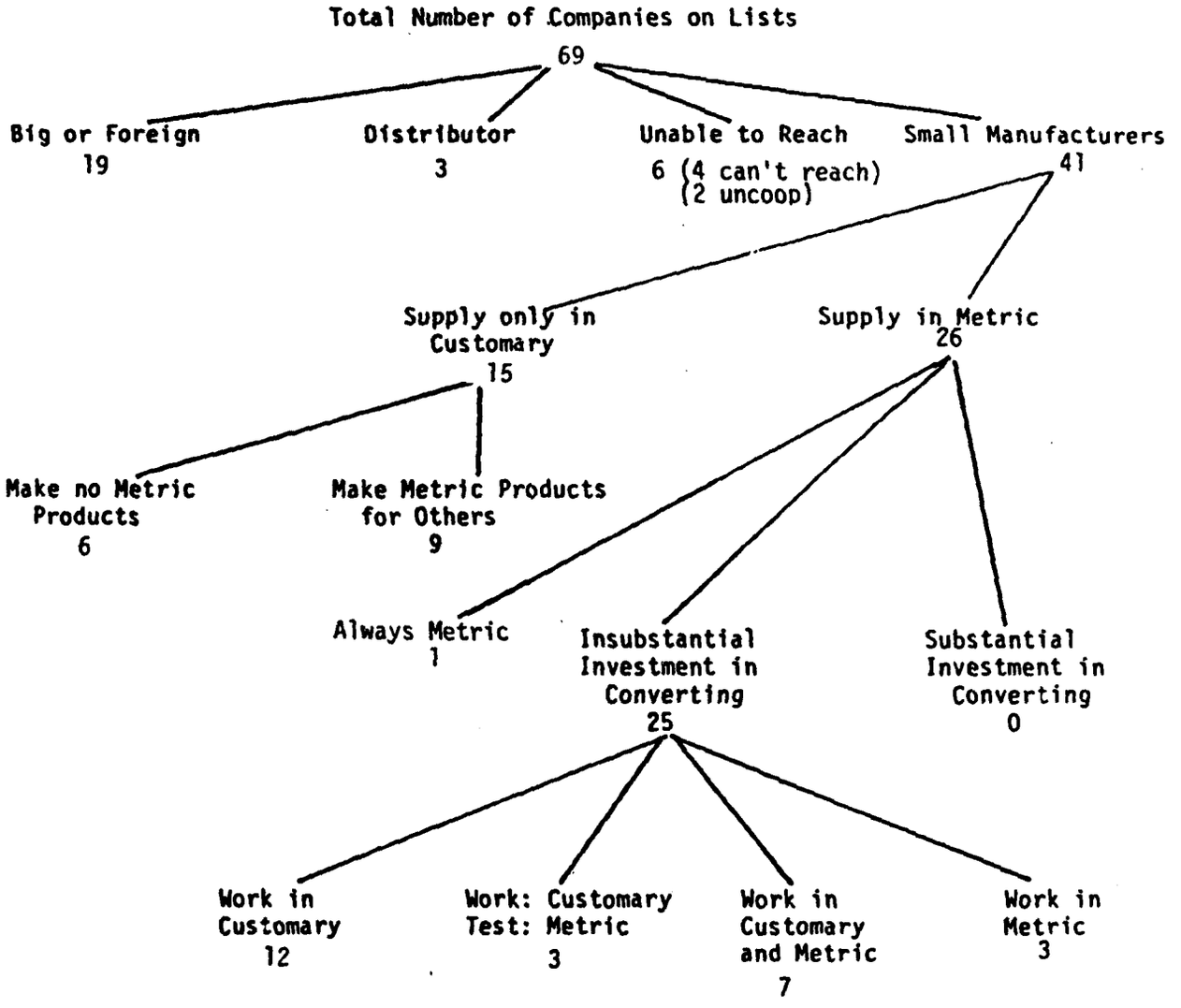
The low level of metric activity among Power Tool's suppliers has created few problems. Several noted problems with getting metric supplies. Suppliers also do not see any benefits from converting to metric. Most said converting only served to keep existing customers' business.

Summary

Power Tool and its metric suppliers agree that Power Tool's conversion has been easily accomodated by suppliers. Exhibit 41 summarizes the suppliers' experiences. Power Tool does not dominate its suppliers' metric business. For the most part, suppliers' involvement in metric is quite small. Many companies choose to deal with the occasional metric order by converting to customary. Few firms invest in developing a metric capability; the demand for metric among their customers does not warrant it. The metric suppliers to Power Tool see few problems from conversion. They also see few benefits from conversion.

Exhibit 41

METRIC ACTIVITY IN POWER TOOL SUPPLIERS



IMPORTANT NOTE

There is some confusion about the role of the U.S. Metric Board and the national policy on metric conversion

Congress established the Board to plan and coordinate the voluntary increasing use of the metric system. It is not, however, the role of the Board to promote metric usage.

The Board is an independent Federal agency responsible for conducting public information and education programs and appropriate research, coordination and planning activities.

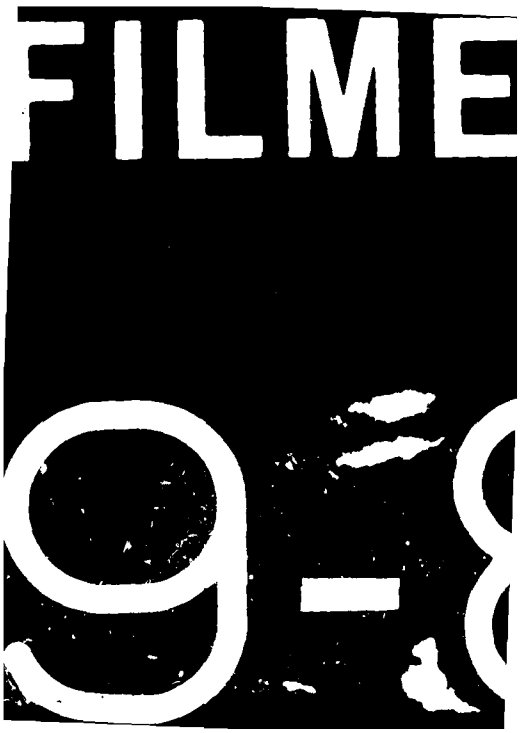
Metric Conversion in this country is voluntary. When Congress passed the Metric Conversion Act in 1975 it did not make conversion mandatory; nor did it establish a target date or deadline for conversion.

The Board has no compulsory power. It is a public service agency consisting of citizen representatives from all walks of American life. Its 17 members are appointed by the President and confirmed by the Senate. Members are nominated to represent labor, retailing, small business, industry, construction, state and local governments, science, engineering, consumer groups and the public at large.

Please contact us if you have any questions about the role of the Board or the national policy on metric conversion.

UNITED STATES METRIC BOARD

Suite 400
1800 Wilson Boulevard
Arlington, Virginia 22209


FILME